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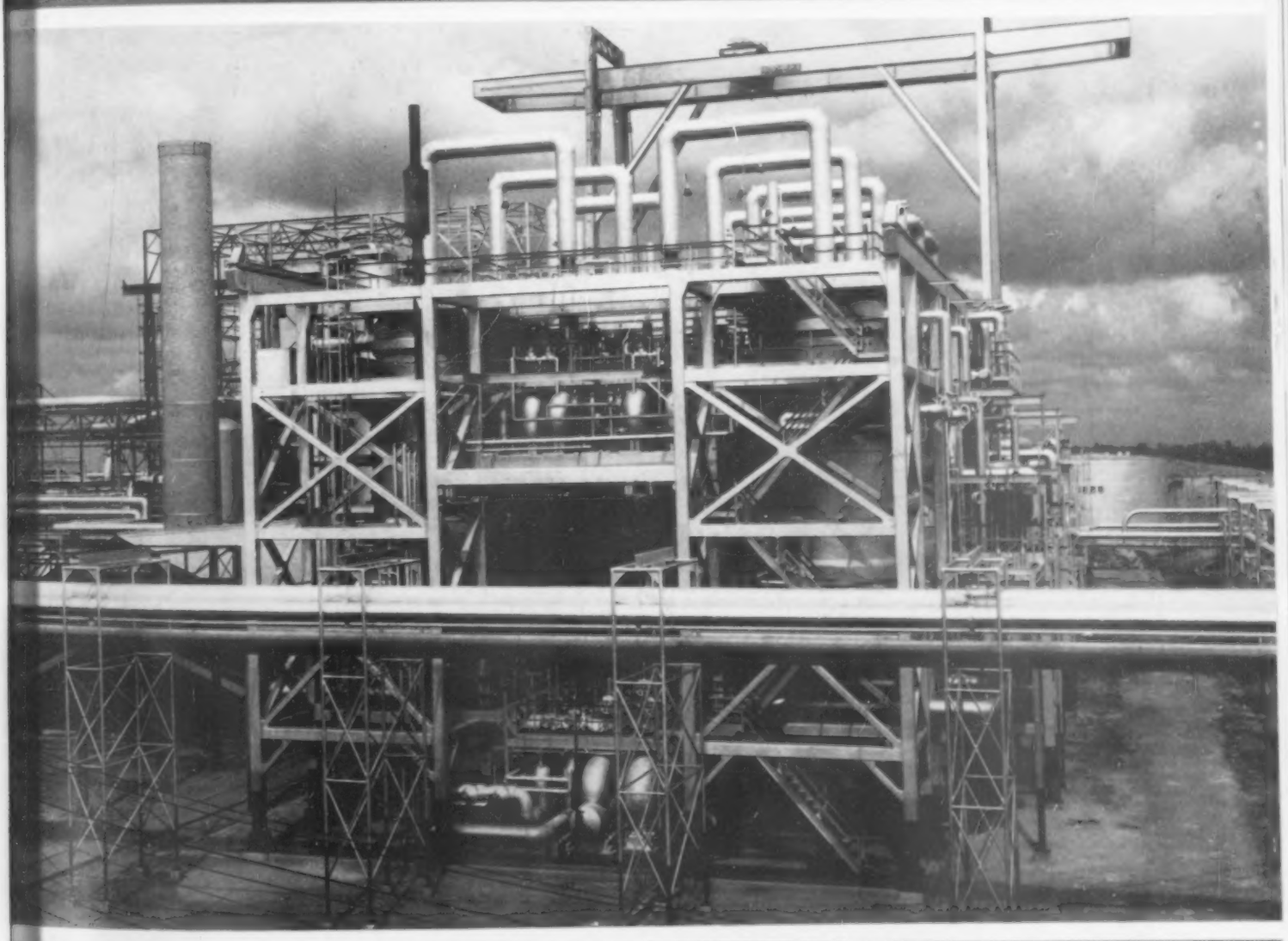
The WELDING Journal



The Journal of the American Welding Society

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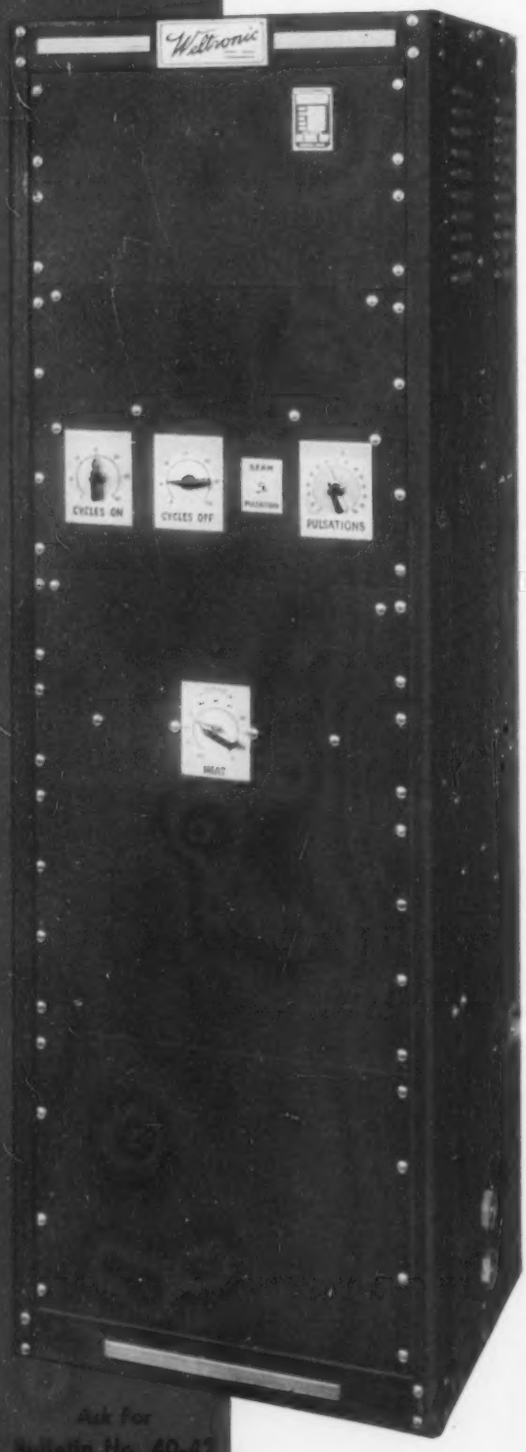

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Welding in Aircraft Construction and Maintenance*

By A. K. Seemann†

THE past decade has witnessed a number of changes in the design and fabrication of aircraft. This, as should be expected, is normal and finds analogy in the growth and development of the automotive industry. There is this distinction between the aircraft industry and the automotive industry, however. In the aircraft industry fundamental design changes develop so rapidly that there is no opportunity to set up a production line for even a matter of months. The best planes of today are obsolete tomorrow, and design changes take place even while the planes are being manufactured. As a result, despite the aircraft production figures published, the building of today's airplanes is largely a manual job with little opportunity to incorporate standard economical procedures such as are common in more completely developed industries.

In view of these facts the aircraft industry is to be complimented not only because this country produces the finest planes in the world but also because these planes have been produced under handicaps not found in other industries. The aircraft manufacturer has learned that only change is constant, and has learned to accommodate manufacturing facilities to this constant change.

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The earliest planes employed stick and wire structural members. Then, during the first World War, the welded tubular steel fuselage was developed, and more recently the stressed-skin monocoque fuselage of riveted aluminum alloy has come from the designer's board. The end is not here, for the airplane of tomorrow—of a size not now conceivable—may well be large enough to justify the high-strength–weight ratio of welded alloy steel in monocoque structures. At the present time important highly stressed and heavily shocked structural members of military and commercial aircraft are of welded construction. To date the welded tubular steel fuselage remains supreme in the field of civilian and training planes. A number of examples of oxyacetylene welded fuselage parts are shown in Figs. 1 to 4.

It is no mere accident that oxyacetylene welding has been adopted for heavily loaded primary structures. Through the years the welded joint has amply demonstrated its dependability, its ease of fabrication and its ease of repair, evidenced in no small part by its intelligent use in the fabrication of aircraft. In adopting the welding blowpipe as a fabricating tool of extreme importance, the aircraft industry followed the example of the metal-working industries, where it has been in long and successful use.

It has already been mentioned that the building of modern aircraft is a manual task and likewise aircraft

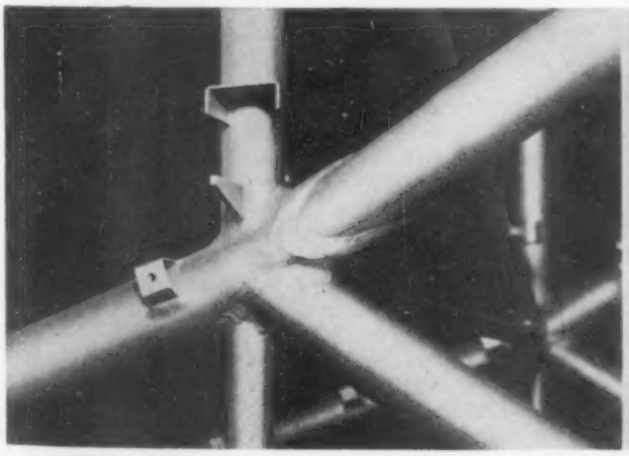

Fig. 1
This close-up of a joint in tubing shows the flexibility of design possible in oxyacetylene welding.

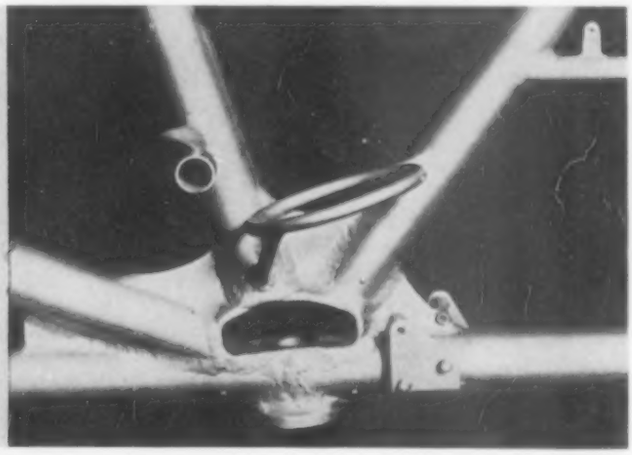

Fig. 2
In this example of welded joint design, various converging tubular members are joined to a special fitting for a control. The welded joint is strong and adds a minimum amount of weight to the structure.

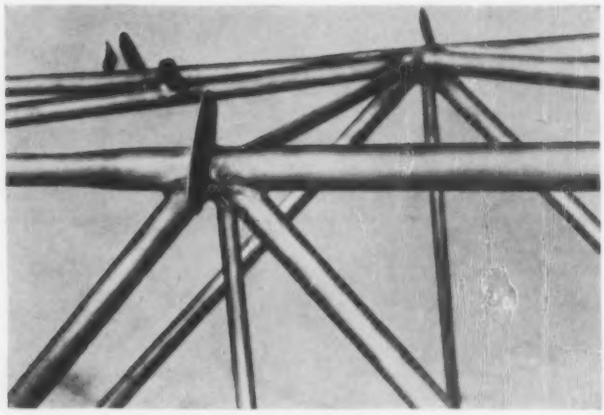

Fig. 3

This section of a welded fuselage illustrates the use of step-tapered tubing, with the welds located just back of the "step."

welding is a manual task. Being manual the process must be so supervised that uniformly good results will be obtained. This has been assured by the adoption of a procedure control for each job; in other words, a written specification which includes the essential elements of:

1. Design for welding.
2. Selection and inspection of materials.
3. Establishment of a procedure which will give the results desired.
   (*a*) Preparation of material.
   (*b*) The welding procedure.
4. Qualification of the welding operator to follow the procedure.
5. Inspection and testing of completed work.

It is not the purpose of this paper to discuss the several procedure-control principles in great detail. Rather an effort will be made to present detailed information on certain of the elements which have been troublesome to both the engineering and production departments.

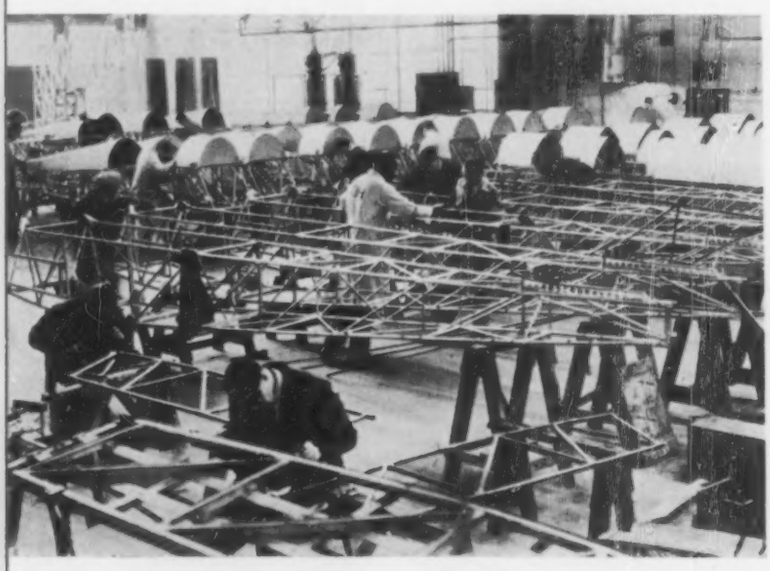

Fig. 4

The large-scale production of aircraft fuselages by oxyacetylene welding is shown in this view of a Canadian plant where trainer planes are being built.

Design for Welding

Basically the Army and Navy authorities and Civil Aeronautics Board, singly or in combination, have formulated specifications regarding designs and materials covering fundamental designs. We may expect these designs to be improved and refined as new knowledge is developed. However, it is thought that all too often designers and engineers have little fundamental knowledge of welding and assume that any two pieces of metal may be joined regardless of their shape, size or position. It is easy to label a drawing "weld here" but often it is difficult to fabricate the original design. Well-organized plants always consult the welding shop concerning new designs in an effort to make changes compatible with welded fabrication. In common with other methods of joinery the design must include an understanding of the joining process.

The commonest steel used in aircraft construction is S.A.E. X4130. It was selected because of its high physical properties and the fact that it is available in desired shapes and can be fabricated with little difficulty. S.A.E. X4130 is an air-hardening steel which is hot-short, a property which must be taken into consideration if cracking difficulties are to be avoided during the welding operation. Many empirical expedients have been and are being used in aircraft plants but it is believed that a knowledge of the causes of cracking will enable the engineering and production departments to take the necessary corrective measures to insure sound strong joints.

The Cause of Cracks

It is quite obvious to state that cracking results from the liberation of tensile stresses; otherwise there would be no cracking. We may then argue that no cracking will occur if these stresses are absent or are so slight that they do not exceed the strength of the metal at any time during welding. In welding, steel is first heated to the fusion temperature. While the cooling, solidifying metal is at a white heat, it is devoid of ductility, because although the individual grains have solidified, they do not cohere to each other. Any slight force will pull the grains apart, air will enter at the grain boundaries and what is termed a "heat crack" will occur.

A study, then, of the forces which are encountered in welding provides a basis for the study of crack elimination. First of all, we know that forces are developed through the expansion on heating and contraction on cooling. Second, we know that there may be residual stresses in the metal parts themselves, which are liberated by the welding flame. Third, stresses may be introduced in the welding operation. The majority of the "heat cracks" fall into the first group, that is, those developed by expansion on heating and contraction on cooling. Typical of this type of crack is the "edge crack," which starts at an external edge of a part and follows the weld into the part.

It is a matter of common experience that when two pieces of sheet metal are butted together or when one is lapped over the other, they will come together in the first instance, or move together scissors-like in the second instance, when welded along the seam of the two edges. A crack is liable to start at the edge where the weld is begun. The following analysis of the forces at work is offered in explanation of a crack of this type.

After the weld has progressed slightly from the starting

point at the edge, two forces begin to operate, both tending to stretch the metal at the point where the weld was begun. One of these forces is produced by the contraction of the solidifying metal. This of itself would tend to produce a crack. In addition, the weld metal just inside the starting point solidifies faster than the edge or starting point because of the more rapid conduction of heat away from it by the adjacent metal. The air surrounding the free edge or starting point is a relatively slow cooling medium; consequently, while the initial point is still at a white heat the next interior stage has cooled to a yellow heat. In other words, the edge is lagging behind and is still in the tender or brittle condition when the adjacent stage along the weld is in the tough and ductile condition. This intermediate point acts as a fulcrum, so that the scissors-like action, which brings the edges of the seam together, tends to stretch the white-hot brittle starting point of the weld. Moreover, as already stated, the shrinkage is also stretching the same point, and if the combined effect is great enough, a crack occurs. The manner in which these forces act to produce cracking is shown in the sketch in Fig. 5.

The considerable amount of contraction which occurs when metal freezes and cools is not generally appreciated. Not considering the contraction of the cooling but still molten metal, and starting instead at the moment of solidification, the metal shrinks about 5% in volume in merely changing to the solid state. An additional contraction of almost 1% then occurs before the temperature has fallen to a yellow heat. Still another contraction of 1% takes place when the metal cools from a yellow heat to ordinary temperature. This sudden and considerable contraction is only one of the stretching or cracking forces that must be controlled intelligently in welding. If the solidifying metal could stretch, it would not crack; or, if the adjacent parts could yield, the contraction could be compensated.

Usually cracks are located in the base metal right at the edge of the weld. There are several reasons for this. The principal reason for this particular location is that the section is thinner than the weld and its shape changes more or less abruptly at this point. In the second place, the base metal, because of its nature, is usually more tender at a white heat than the weld metal. Third, the thin section at the starting point on the edge remains hotter a trifle longer than the thicker, reinforced section of the weld just inside the edge. This is especially true of the lap seam where the double thickness of base metal causes a more rapid cooling rate.

An obvious remedy for the edge-type of crack has been recognized and adopted by some plants, namely, to begin the weld at some point on the seam and weld toward an outside edge rather than to start at an outside edge and weld inward along a seam. A slight compensating compression is thus brought to bear on the weld.

Sometimes the forces operating on a weld compensate or neutralize one another, and since the net result is zero, the metal is not stretched or cracked. In other words, although contraction always takes place, there may yet be forces of compression exerted in the surrounding areas which squeeze the contracting area. On the other hand, external conditions or a combination of circumstances may be such as to exaggerate the cracking tendency. The adjacent parts may be so rigid, either from their massiveness or because of being held immovable, that pure contraction occurs, resulting in a crack.

Conditions conducive to another type of cracking, known as interior cracking, can be overcome by a "double-welding" technique, which is particularly useful

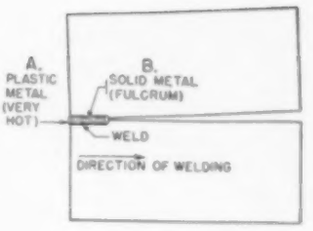

Fig. 5

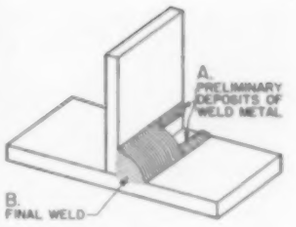

Fig. 6

(Fig. 5) Since point *A* has less metal surrounding it to carry off the heat of welding than does point *B*, it solidifies more slowly, even though it is welded first. While *A* is still molten, *B* has solidified and acts as a fulcrum about which the remainder of the plate draws together as the weld progresses. This force, added to the natural shrinkage of the cooling metal, tends to pull *A* apart.

(Fig. 6) As a means of avoiding interior cracking, particularly when thin material is joined to thick material, such as a tube to forging, the "double-welding" technique can be used. The first step (*A*) is to deposit weld metal on both materials, along the lines of the outer limits of the proposed weld. The weld metal should be fused with the base metal, but no attempt should be made to obtain deep penetration. The main weld (*B*) is then made between the two original weld deposits, and fused with them. In this manner an abrupt change in section is avoided, cooling takes place less abruptly since the original weld deposits serve to preheat the base metal and residual stresses in the base metal are removed prior to the main welding operation.

in joining thick material to thin material, such as a forging to a tube. Welding with this technique is performed in two steps. A deposit of weld metal is first made on both materials to be welded, as shown in Fig. 6 (*A*), following the outer limits of the proposed weld. The weld then is made, as shown in Fig. 6 (*B*), care being taken to terminate the weld within the original deposits of weld metal. In this manner an abrupt change of section is avoided, cooling takes place less rapidly and residual stresses in the base metal are removed prior to the welding operation.

It should be appreciated that a weld is a casting and that good casting practice is also good welding practice. In a foundry, for instance, the melting and casting procedures affect the tendency to produce heat cracks, and pouring is performed as near the solidifying temperature as practicable. The welding operator, then, should employ similar principles. The welding flame, through proper adjustment, should be slightly reducing or neutral, but in no event oxidizing. The rod should contain beneficial ingredients which will further assist in avoiding oxidation, and for this reason a rod of the same composition as the base metal is seldom satisfactory. Likewise, the metal should not be overheated.

Mention has already been made of the tensile stresses created by contraction of metal on cooling. It may be convenient to compensate these forces mechanically or thermally. Jigs may be so designed that a slight compressive force is exerted during the welding operation but obviously this force should not be of sufficient magnitude to cause upsetting. If the parts to be welded are so positioned that end-wise movement is prevented, the local application of heat to the metal adjoining the weld area produces compressive forces sufficient to compensate for the contraction and thus avoids tensile stress on the part during cooling. This can be accomplished by local heating with the blowpipe, or, as practiced in a few plants, by enveloping the weld in an oxyhydrogen flame. This expedient has the added advantage of insurance against oxidation, but has the obvious disadvantage of increased welding costs. Entirely satisfactory results are obtainable by local preheating with a properly adjusted oxyacetylene flame.

Local preheating also serves to eliminate another

cause of cracking. Tubing and sheet metal are not always stress-free prior to welding. This condition is brought about by such cold-working operations as straightening, bending, forming and rolling. Residual stresses resulting from these operations are not usually uniformly distributed, and in localized areas may be sufficiently great to cause cracking if they are released during welding. Preheating these areas locally to a dull red will relieve the major residual stresses, and can be performed as a part of the welding operation.

There is a third cause of cracking which is relatively unimportant but which should be considered during examination of any cracked parts. If at the conclusion of the welding operation the part is stressed while hot, cracking may occur. Such practices as dropping parts out of jigs, careless or rough handling and use of improperly designed jigs may cause enough stress to cause cracking.

In review, then, there are three kinds of cracks: (1) those which originate from the heat of welding, (2) those which result from stresses which reside in the metal and are released by welding and (3) those which are introduced after welding. An understanding of the principles underlying each cause enables the designer or operator to prevent their occurrence.

Selection and Inspection of Materials

The customary specifications are adequate for selecting aircraft steels but inasmuch as there may be future changes for steels of higher physical properties, the following remarks may be of interest.

For a number of years the requirements of strength, impact resistance and ductility were satisfied by medium carbon steel, usually S.A.E. 1025. As higher-strength steel was required a careful search for a steel with the desired properties resulted in the selection of S.A.E. X4130, a chrome-molybdenum steel containing about 0.30 carbon. S.A.E. X4130 has been adopted almost universally and combines the desired physical properties with good machining and welding properties.

However, with aircraft becoming larger, faster and more heavily stressed, designers and engineers are searching for a steel superior to X4130. One steel that offers attractive possibilities is S.A.E. X4340 which is a nickel-chrome-molybdenum steel containing about 0.40 carbon. This steel possesses the desired physical properties and, as normalized, has a tensile strength in excess of 150,000 psi. Preliminary experiments now undergoing confirmatory test indicate that this steel has good weldability, a necessary requirement for all good aircraft steels. Welded joints have been normalized and submitted to tension testing with failure occurring only in the tube. The welding procedure employed with this steel is conventional, a slightly excess acetylene flame being used. Several welding rods have been tried and to date a low chrome-molybdenum, low carbon rod has produced the best results.

Establishment of a Procedure

It has been observed that both the establishment of a procedure which will give the desired results and the qualification of welding operators who are to follow this procedure have not been given all the attention they

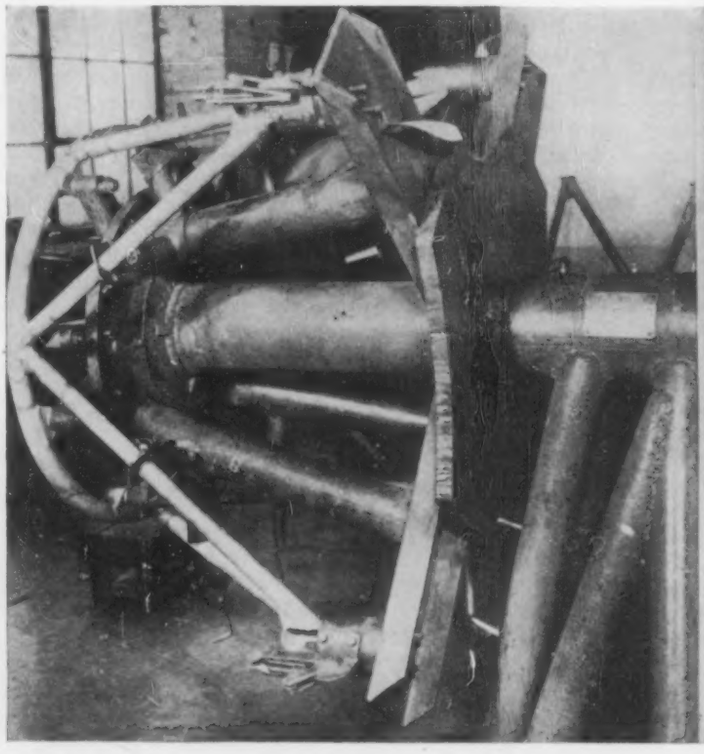

Fig. 7

Here can be seen a complete engine-mount assembly ready for welding in a welding jig which holds the parts in alignment and positions the assembly for welding. The jig can be rotated, permitting two welding operators to work simultaneously.

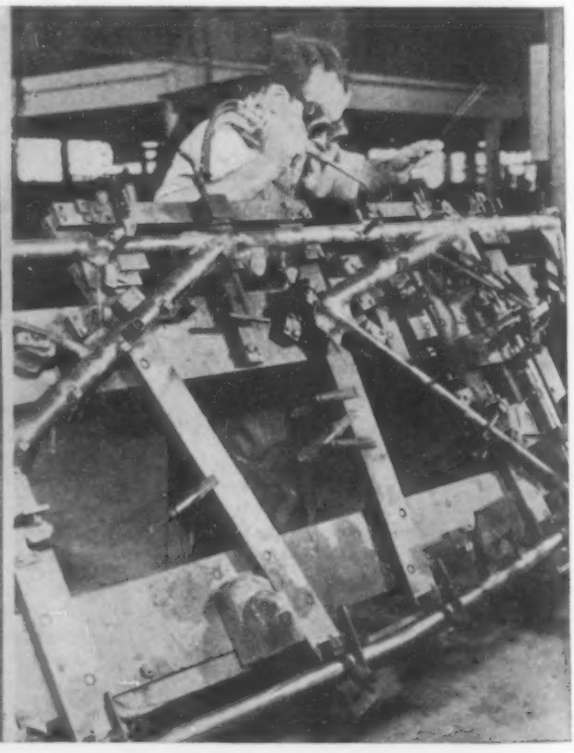

Fig. 8

This large side section for a fuselage, made up of heavy tubular members, is also being welded in its special jig. The jig is suspended on end pivots so that it can be tilted to bring the work into the most convenient position for welding.

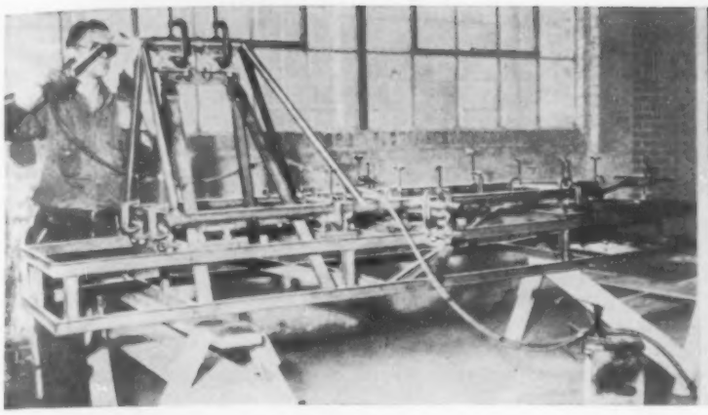

Fig. 9

In addition to its regular use in aircraft construction, oxyacetylene welding—particularly bronze-welding—provides a convenient means of fabricating various equipment needed in the factory. This jig, shown in use for the welding of a propeller dolly, was fabricated from angle iron and light I-beams entirely by welding.

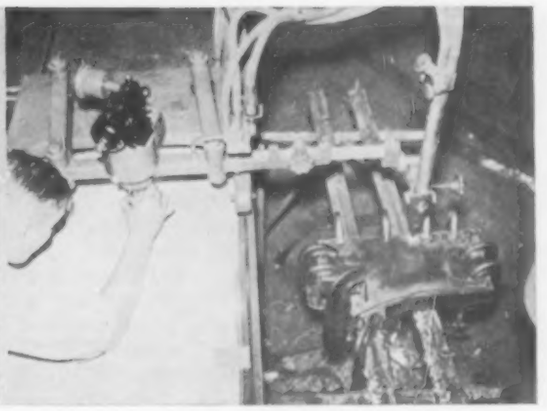

Fig. 10

As a further example of the versatility of oxyacetylene processes, oxyacetylene cutting machines can be used to flame-cut special shapes as needed from steel plate and sheet. Shown here is the cutting of an intricate shape in a stack of 100 sheets of light-gage steel. The operator is hand-tracing the desired shape from a drawing.

deserve. Frequently the establishment of a procedure is left up to the welding foreman or a man who is considered a "good welder." When the welding has been completed, the welded part is visually examined, checked for measurement and usually tested by the Magnaflux method. It is then assumed that the part is what the designer expected. However, in well-organized shops where good results are obtained consistently, a conference is held over each new design. Estimates are made of the amount of allowance needed for expansion and contraction, the direction of welding is decided upon, as well as the starting and stopping points. The various parts of the design are then prepared carefully to give a close fit, and the welds are made in accordance with this plan. If difficulties are encountered in the sample parts, the welding sequence is studied again and a new plan evolved. The parts are then subjected to appropriate testing in accordance with the types of stress for which the part has been designed.

With the completion of suitable welding jigs, such as those shown in Figs. 7 and 8, the procedure for welding is marked on the blueprint. These markings include the starting and stopping points of all welds, the direction of welding and the welding technique. All operators are then required to follow this procedure exactly.

Welding Technique

A slightly excess acetylene flame adjustment is recommended for welding X4130 steel. One important reason for this is that the slight amount of carbon in the

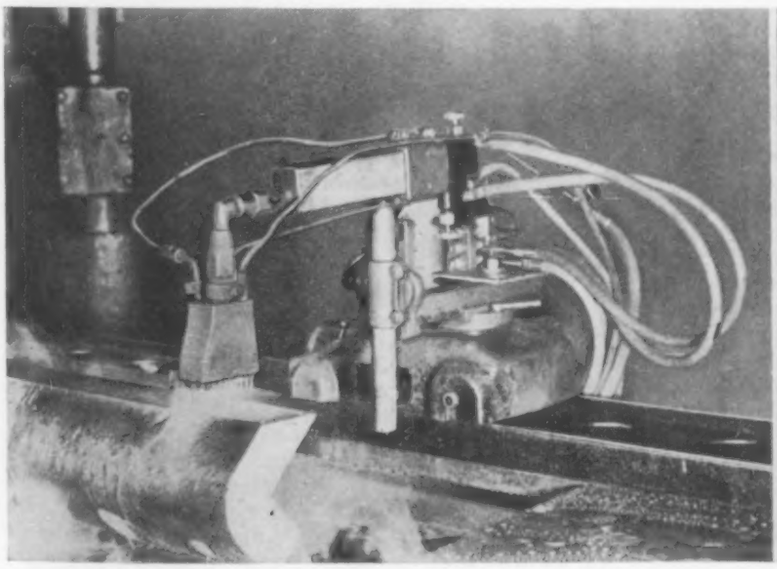

Fig. 11

The oxyacetylene process also offers a convenient and economical means of imparting a wear-resistant surface to certain fabricating equipment parts of quench-hardenable iron or steel, without affecting the ductility and shock resistance of the core. In this process, a series of oxyacetylene flames are passed over the area to be hardened, followed by a quench.

Fig. 12

In the aircraft factory, as in all industrial plants, there is much piping that can be installed effectively by oxyacetylene welding.

flame has a fluxing action which is of considerable aid in reducing surface oxides; yet such a flame adjustment does not cause carbon pick-up by the base metal. An added advantage of the slightly excess acetylene flame is that it minimizes the overheating of the base metal with the result that the creation of a temperature gradient in the base metal that is sharp enough to cause the formation of martensite frequently is avoided.

In connection with flame adjustments, it is well to point out that most operators know that an oxidizing flame is hotter than either a neutral flame or a slightly excess acetylene flame and sometimes they will allow the flame to become oxidizing in order to speed up the work. This should be guarded against, and it is important, therefore, that the operators be fully informed of the effects produced by various flame adjustments, and that they be cautioned against using an oxidizing flame.

Qualification of the Welding Operator

In many respects qualification of the welding operator to follow the procedure is the most important part of the procedure control. In welding shops of plants not using a procedure control, practically every welding operator uses a slightly different technique. Some operators weld forehand, while others weld backhand. Flame adjustments vary from slightly excess acetylene to definitely oxidizing flames. The manipulative technique is also subject to great differences between individual operators, and this lack of uniformity serves to explain differences in welding results.

Well-organized shops in the aircraft industry either train their own welding operators or cooperate with the welding schools from whom they obtain them. The fact that welding operators in this industry are confronted with a wide variety of joints calling for variations in welding technique makes it possible to train them gradually but thoroughly. When they are first employed these operators are assigned to work on secondary structures until their proficiency has been determined. As they progress they are assigned to simple primary structures and in keeping with their ability to weld the more complex joints. The engineering and welding departments cooperate by determining the correct welding technique for each job and by giving qualification tests to determine the ability and talents of the operator. These tests are carefully designed to include the commonly encountered joints and will therefore indicate on which types the operator is most efficient, as well as demonstrate his average ability. In order to insure uniformly high-quality work, destructive tests of production parts are made at random and, inasmuch as each weld is marked with the operator's brand, it is possible to identify each one's work, and thus have an individualized control. These tests are made in addition to the customary semi-annual qualification tests, which have their effectiveness somewhat reduced by the fact that the operator knows them to be tests, and the test specimens are naturally samples of his most careful work.

Inspection and Testing of Completed Work

For many years no adequate non-destructive test of welds was available. Later Magnaflux testing was developed and the vast majority of plants now use this test to determine weld quality as revealed by any discontinuities of metal structure. This, in addition to visual inspection by qualified inspectors, is adequate to insure the necessary high quality required of aircraft welds.

Maintenance Applications

The versatility of the oxyacetylene process is perhaps best illustrated by its employment as a repair and maintenance process in addition to its primary role as a production tool. Fuselage and subassembly structures require jigs in order to meet dimensional specifications and interchangeability. Jigs, such as the one shown in Fig. 9, are easily fabricated from structural shapes by the cutting and welding blowpipe. Bronze-welding of jigs is particularly advantageous because not only is the assembly quickly fabricated by this method, but also design changes can be made quickly by melting the bronze from the joint.

Oxyacetylene cutting machines are another oxyacetylene tool which have reduced costs and speeded up production. It is no longer necessary to prepare metal parts laboriously by mechanical devices, since the cutting machine will flame-cut many parts simultaneously in sheet or plate, as shown in Fig. 10.

Often it is necessary to bend or form sheet or plate preparatory to welding. Attention has already been directed to the cold-working stresses introduced by these operations. This danger is avoided and the task greatly simplified by heating the metal part with the ordinary welding blowpipe prior to forming.

Also, it is well known that the oxyacetylene blowpipe can be used to heat-treat steel parts locally, and aircraft manufacturers have adopted both the flame-hardening and flame-softening processes in building and maintaining machines of various descriptions. Figure 11 shows a flame-hardening operation in progress.

Aircraft plants have many things in common with other factories, and we find that not only are the oxygen and acetylene piping systems welded, but the water, steam and other service lines are welded, as shown in Fig. 12, in order to obtain leakproof and trouble-free systems.

In mentioning these several maintenance applications no attempt is being made to present a complete list. Rather it is hoped that the several items will suggest to the operating department that the oxyacetylene process may be used to advantage in many places other than in production welding.

Summary

Over a period of years welding has occupied an important position in the fabrication of aircraft. Problems peculiar to the industry have arisen and, where an intelligent application of procedure-control principles has been applied, the desired uniform high-quality results have been obtained. The close cooperation of management and shop is essential and, coupled with the ever-expanding knowledge of the process, no problem need remain unsolved. The industry should not overlook the many plant maintenance applications which are in daily use in other factories throughout the country.

Flame Hardening of Round Surfaces*

By Stephen Smith†

UNDER the stimulus of the war production program, new and broader applications of flame hardening have been developed. In many of these instances the flame process of hardening steel has been adopted because the characteristics and advantages of the process render it the most suitable solution to the peculiar problems arising from the war situation. Much of the increased attention to flame hardening has come about because of expanding ordnance demands for steel parts capable of resisting batter or wear in military service. More important than this is the fact that the flame process is effective in hardening plain carbon steels, producing wear-resisting surfaces previously obtained by the use of alloy steels. Other methods of hardening are likely to affect core ductility unless alloy steels are used, and as such alloys have become difficult if not impossible to obtain, for many purposes, the commoner steels must frequently be used for parts requiring high hardness. This offers no obstacle, for with flame hardening even the 0.30 to 0.35 carbon steels can be brought to satisfactory surface hardness.

Unlike furnace hardening, in which the entire piece must be heated to hardening temperature, the flame process permits localized treatment of only those surfaces requiring a high degree of hardness, leaving the base metal unaffected, and causing no change in composition of the hardened sections. Both the degree and the depth of hardness may be closely controlled, and the transitional zone between the hardened and unhardened areas is characteristically gradual. The distortion which is a frequent consequence of furnace hardening is virtually eliminated, since the heat of the flame need not penetrate more than a relatively shallow depth, and the entire heating and hardening operation may be confined to a small portion of the piece. The flexibility of application and operation, a characteristic of all flame processes, prevails in flame hardening as well, and since the hardening is done on finished surfaces considerable savings in machining time are possible.

While much has been written on the technique of flame hardening, these accounts could not do more than hint at the numerous variations in technique which may be devised for hardening round or cylindrical surfaces. Generally, the method used for flat surfaces is simple enough, and requires little special apparatus. For hardening round sections there are four general methods which may be used, and refinements to these may be worked out when the quantity of production warrants development of special apparatus. These four techniques are described as:

Band progressive.
Spiral band progressive.
Band spinning.
Progressive spinning.

The method chosen for a particular job depends on the nature of the work and upon facilities available, though the most satisfactory, uniform hardness is produced by the "spinning" method.

Essentially the two "progressive" methods are direct adaptations, to circular work, of the technique applied in hardening flat surfaces, where the work is moved slowly past the heating flames and quench jets. In the spinning technique, on the other hand, the work is revolved at fairly high speed before the flames, heating entire circumferential areas before quenching. The advantage of this method is that overlaps or soft zones are eliminated. All of the four methods are applicable to hardening either external or internal surfaces, continuously or in localized bands.

Band Progressive Method

Large diameter cylinders, rolls, shafts and sleeves may be flame hardened by the band progressive method. The work is usually mounted on a lathe or other machine which can be geared to rotate the work at circumferential speeds of from 3 to 10 in. per minute. The heating tip is then mounted on the lathe carriage tool post or similar mount capable of lateral movement parallel to the axis of rotation of the work. The multiflame tip is water-cooled and may have a built-in quench, or be followed closely by a separate quenching stream. Hardening is accomplished by rotating the work past the flame at a peripheral surface speed which may range from 3 in. per minute for a $^1/_4$-in. depth of hardness, to 6 in. per minute for a $^1/_{16}$-in. depth. These figures are subject to some variation according to the thickness of the object heated.

Upon completion of one revolution of the circular object the flames are extinguished and the heating tip shifted to a new position for hardening the next adjacent band. A narrow space of $^1/_8$ to $^1/_4$ in. should be left between tip positions to allow for heat conduction outside the flame-swept zone. As additional precautions against overlapping or reheating of hardened bands, extra quench jets should be provided at both ends of the heating tip, and in some cases an auxiliary cooling flow of water may be directed at the adjacent zones. This should be held as close to the flames as possible.

The band progressive method is generally used in cases where it is not essential that the hardness be perfectly uniform over the entire length, and on parts whose extremely large diameters make it economically and mechanically impractical to employ the spinning methods. It is also employed on parts having flanges or shoulders which confine the area to be hardened, for the shoulders sometimes prevent the use of the other methods.

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Spiral Band Progressive Method

While the foregoing method is suitable for hardening either localized bands such as bearing surfaces, or for treating the entire length of a shaft or cylinder, the spiral band progressive method is somewhat better suited to the latter type of work. In this method the heating tip is moved laterally, as the work revolves, at such speed as to move one tipwidth along a line parallel to the axis with each complete revolution of the work, thus heating a continuous spiral band covering the entire surface of the work in one operation. The same precautions against overlaps and edge zone softening should be observed as in the band progressive method, and in addition a separate water quench should be provided at the ends of the work, to prevent burning of the edges as the flames start and finish the spiral. The advantage in this technique is the elimination of soft end zones, which occur at the starting-stopping point of each band in the band progressive method.

Heavy spiral threads may be flame hardened using an adaptation of this technique. Instead of a broad, multi-flame tip, a two-flame bulbous type flame tip is recommended, one flame serving as a preheater. Torch travel

Fig. 2

The depth to which hardening may penetrate is readily controllable in the spinning method. If desired, the shaft may be hardened all the way through as at right, though shallow surface hardening is usually preferable since core ductility is retained.

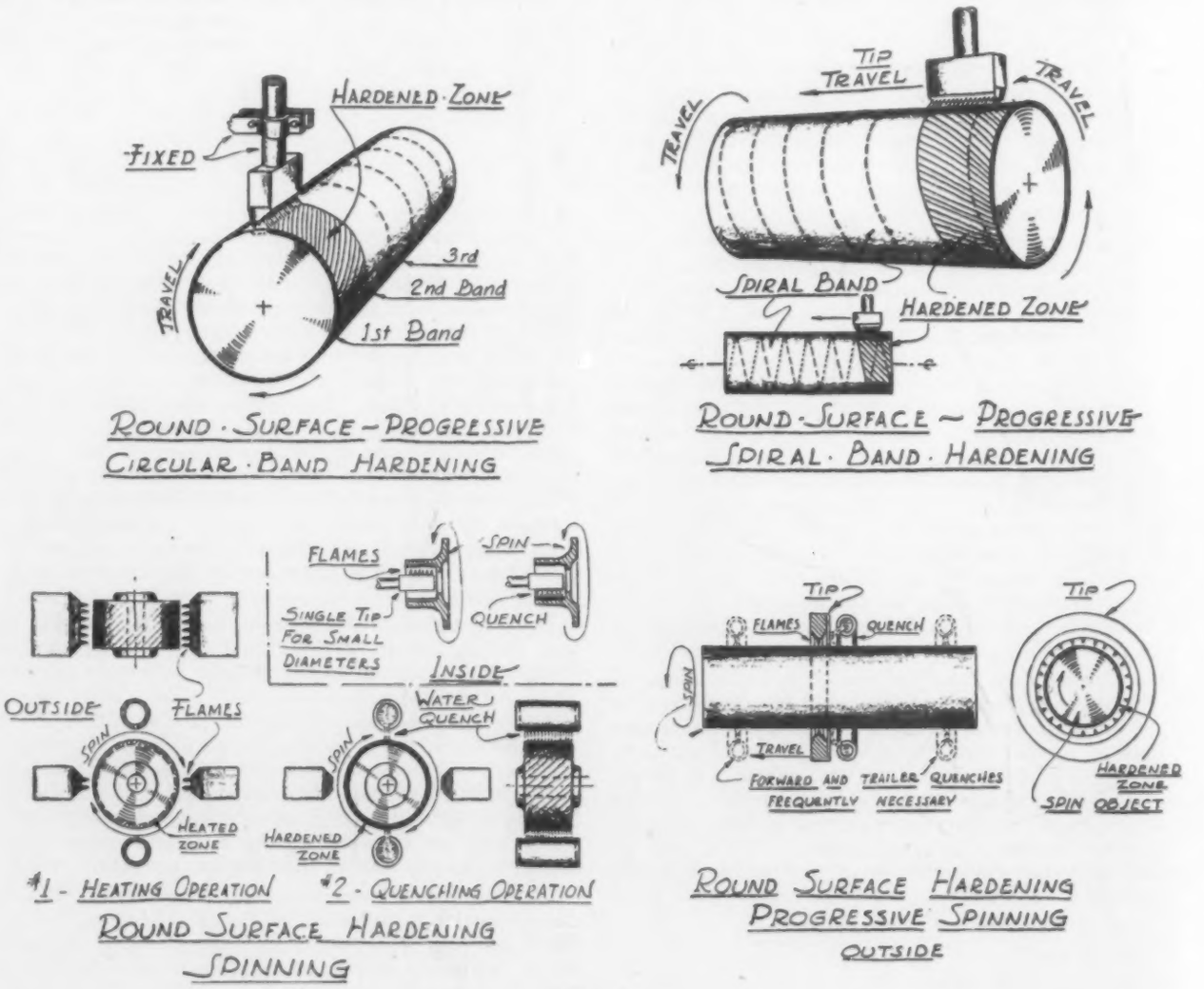


Fig. 1

These four diagrams show schematically the four techniques for flame hardening cylindrical surfaces. Each has specific fields of usefulness, though generally the slow-rotation progressive methods are used for large diameter objects, and the spinning methods, on quantity production work.

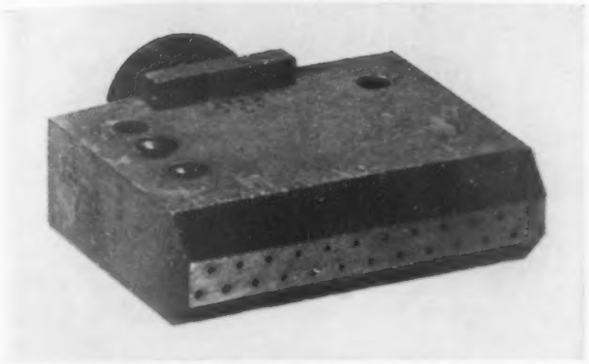


Fig. 3

A standard flat flame-hardening tip as, wide as practicable, is used in progressive band and spiral methods. These are water-cooled and, for the lighter work, have a self-contained quench.

is synchronized with the thread turns, with both flames directed at the root of the thread. Quenches are provided immediately behind the flames, covering two threads, and a secondary quench is placed several threads behind. The size of tip and distance from the work vary with the thread size, and must be determined in practice. Quenches must be so positioned as to prevent any drawing action from the areas already hardened.

The method described above may be applied to hardening small Acme and worm threads, and large Brown and Sharpe and Acme screw threads. Large worm threads are hardened in the same way except that standard gear hardening tips are employed, providing for uniform heating and hardening of both sides of the thread.

Where it is impractical to set up large cylindrical objects on a lathe, they may be mounted on a pair of rollers and rotated by suitable means. Torch movement is then provided by mounting the heating tip and quench on a Radiograph or other machine capable of giving slow lateral motion parallel to the axis of rotation of the work, and synchronized with its rotation to effect a spiral hardened band without overlapping. This setup is used principally on external surfaces, but it may also be applied to large diameter internal surfaces.

Band Spinning Method

For hardening comparatively narrow bands of complete circumference the band spinning method produces far better results than the progressive method previously described, principally because soft zones are eliminated. It is best applied to small and medium diameter cylindrical objects, and may also be used for small gears and screws. There are no overlaps or soft zones, and the uniform, over-all heating before quenching permits hardening to any desired depth of penetration. Where the quantity of production warrants the increased investment in equipment, the spinning method is by far the most satisfactory.

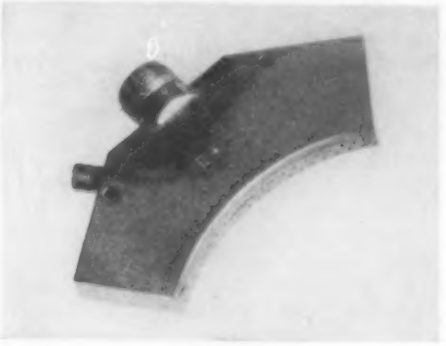


Fig. 4

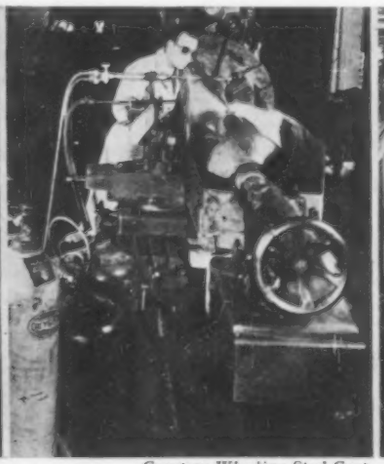
Two or more segmental flame-hardening tips form a ring of flames around the work for external hardening by the spinning method.

As in the methods already outlined, a broad flat tip of the width of the band to be hardened is employed. Quench may be incorporated into the heating tip, or be separate from it, but in either case the heating and quenching are separate, successive operations. The

Courtesy Westinghouse Electric & Mfg. Co.

Fig. 5

Progressive band hardening of a 63-in. diam. SAE 1040 forged lathe spindle. Speed of rotation is regulated for hardening ⅛-in. deep, producing a hardness of 400 to 450 Brinell.



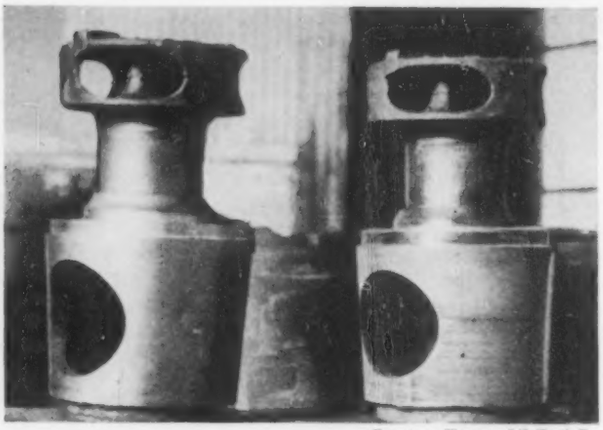
Courtesy Wheeling Steel Corp.

Fig. 6

A tension roll for a tin plate mill, mounted on a lathe, is hardened by the band progressive method. A 4-in. wide flame-hardening tip is used, requiring eleven circumferential turns to completely harden the 42-in. long surface. Hardness is raised from 30 to 95 scleroscope.

Fig. 7

Small gears and clutch parts are spun at 100 r.p.m. for 8 to 10 sec. under the flames on this flame-hardening machine, then are removed with tongs and quenched in oil. SAE 5150 steel is hardened to 78 scleroscope, then drawn at 500° F. to 68 scleroscope.



Courtesy Harner Oil Tool Co.

Fig. 8

Valve plug at left is unhardened, while plug at right has been flame hardened, ready for surface grinding. During the flame-hardening process an auxiliary water quench prevents burning of edges of holes.

work is mounted on a spindle or lathe and revolved at a surface speed of about 1000 circumferential in. per minute. The flames are allowed to impinge upon the work for only a brief period, usually less than 1 min. and often as little as 10 sec. on small diameters. Simultaneously with the extinguishing of the flames the quench is turned on, and plays upon the spinning part until it is fully cooled.

Two or more heating tips spaced equidistant around the work may be used on the larger diameters, to assure a short heating interval and thereby to secure the desired surface hardening effect with shallow penetration.

The speed of this process lends itself to automatic coordination and control. If the parts to be hardened are small they may be automatically released from the spindle and dropped into a quenching bath, rather than using specially located quenching jets. Small gears may readily be hardened by this spinning method, the only precaution necessary being that the flames should be withdrawn somewhat so as not to burn the tops of the gear teeth. The gear revolves in a soaking heat instead of the more intense heat commonly applied, thereby causing uniform heating of tooth faces and root as well as the top.

An example of how automatic control features may be adapted to the spinning process is found in a shop where gasoline engine crankshafts are hardened on four bearing surfaces. Since the four surfaces are not all the same width, the heating time is adjusted for each by a cam movement controlling the lighting and extinguishing of the four sets of heating flames. Heating time varies from 45 sec. for the narrowest bearing to 56 sec. for the widest, and the entire hardening process is completed in 2 min. The work is done on a converted lathe bed, and production on this operation totals 175 crankshafts per eight-hour day.

Progressive Spinning Method

For flame-hardening extended lengths of cylinders, rolls, shafts, liners, fine screw threads and similar objects, the progressive spinning method is superior to either of the first two methods described. It is rapid, and leaves no side- or end-zone overlaps since it is a continuous heating and quenching process, progressing uninterruptedly from end to end of the work piece. Applications of this technique are limited only by the size of the work and the amount of investment in equipment justified. Where the quantity in production is sufficient to warrant the investment in special heating tips and quenching ring, this method is most desirable.

As in the foregoing band spinning method, the work piece is revolved at a circumferential speed of about 1000 in. per minute. Heating tips are usually ring-shaped, and for the larger diameters are composed of segments, each usually served by a separate acetylene supply. The tips are mounted on a suitable carriage to provide lateral motion of from 3 to 10 in. per minute, and are followed closely by a quench ring. The rate of forward travel depends upon the hardness depth desired, and is further affected somewhat by the thickness of the cylinder.

Fig. 9

Hardening the bearing surfaces at both ends of plain-carbon steel shaft for farm machinery, using the progressive spinning method. Two semi-circular hardening tips are employed, with auxiliary quenches. This hardened shaft proves more durable than the expensive alloy steel shaft formerly used for this purpose.

Fig. 10

A system of cams makes the mass production flame hardening of auto wheel hubs fully automatic. This machine is one of five designed especially for this operation, with motorized control of oxygen, acetylene, water and compressed air.

Because of the high rate of heat conduction it is often necessary to provide auxiliary cooling jet rings ahead of, and behind, the heating tips. The forward jet prevents withdrawal of heat from the heated zone in advance of the flames, while the trailer quench serves to prevent heat build-up behind the quench, which might cause a drawing action in the hardened metal. In hardening hollow cylinders, to prevent excessive heat penetration through the wall an internal quench ring may be provided. External cooling jets may be used as an alternative, or if this is not feasible, the interior might be flooded with circulating water.

The application of flame hardening to a particular piece of work may be done in a number of ways, as is evident from the four general techniques described for hardening round or cylindrical surfaces. Which of the several ways is decided upon as best for the work at hand depends not only upon the degree and uniformity of hardness desired, but upon economic factors as well. Within certain limits, all four methods produce satisfactory flame hardening, but each has advantages of its own. The best recommendation that can be made is to study each flame hardening task in the light of experience gained in similar operations, and to set up for production accordingly.

Degree and Depth of Hardness

Plain carbon steels can be successfully hardened when the carbon content is as low as 0.35%. Higher degrees of hardness are obtained with higher carbon steels, best results being secured in the 0.40 to 0.70 range. The degree of hardness depends also upon the rate of quenching, and while hardnesses of 400 to 700 Brinell are obtainable, the maximum is secured by using a quenching stream of sufficient volume and intensity to exceed the critical cooling rate of the steel. In this respect the low alloy steels are particularly suited to flame hardening, because of their low critical quenching rate.

In all of the methods described the depth of hardness is controlled by coordination of the total volume of heat and the speed with which this heat is applied. Penetration is naturally greater at slower rates of heating. The depths of hardness that may be obtained range from a few thousandths to $^1/_4$ of an inch. The superficial depths are more difficult to obtain, and for depths of more than $^1/_4$ in. there is danger of decarbonizing the surface, but since the average requirements for flame-hardened cylindrical surfaces range from $^1/_{32}$ to $^3/_{16}$ of an inch, neither limitation offers a serious handicap.

Vertical vs. Horizontal Positioning

In furnace hardening a long cylindrical object, it is necessary to hold the piece vertical during quenching, otherwise severe distortion will take place. It has been claimed that in flame hardening likewise, distortion will be eliminated by hardening long pieces in a vertical position. It is evident, however, that by the very nature of the flame process, in which only a small surface area is heated at any instant, representing a minor fraction of the mass of the object, there is little if any advantage in vertical positioning. This is because the bulk of the object, both longitudinally and cross sectionally at the heated band, remains cold, and because the simultaneous circumferential quenching of the rotating part provides equal rates of cooling and hardening around the full circumference. Both of these conditions eliminate any disposition toward distortion which might be assumed to arise from horizontal positioning of the part. Experience has shown that the distortional effects of this narrow, shallow heated area are relatively the same regardless of working position.

Vertical flame hardening presents a special problem

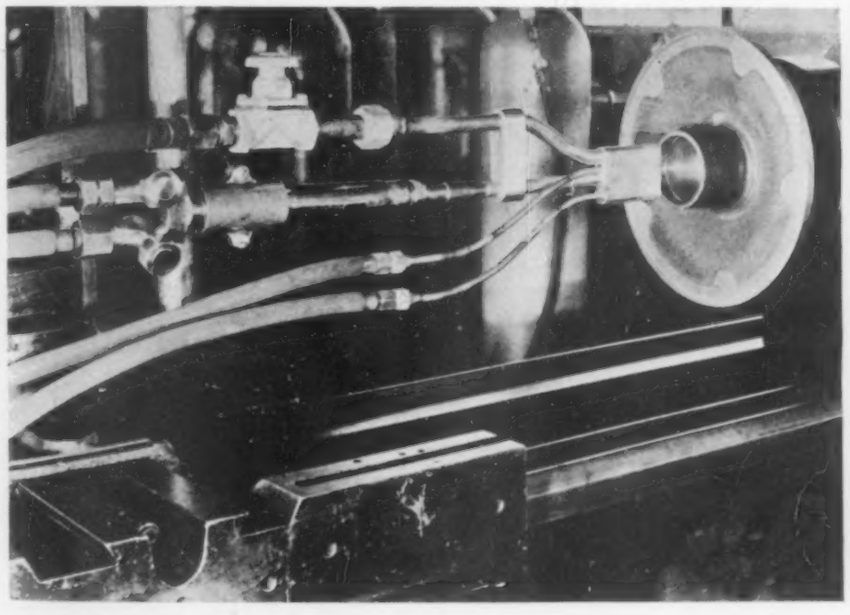


Fig. 11

This heating and quenching tip was designed specially for flame hardening the inside surface of wheel hubs.

Fig. 12

A vertical machine for flame-hardenging shafts and cylinders by the progressive spinning method. The shaft rotates at about 100 r.p.m. while the heating and quenching assembly moves upward at 3 to 10 in. per minute, depending upon depth of hardness desired.

Fig. 13

An improvised flame-hardening assembly, devised from standard welding and heating equipment to fill a need for hardening only a few pieces. Progressive spinning method was employed, with the torches and quench ring carried by the lathe carriage.

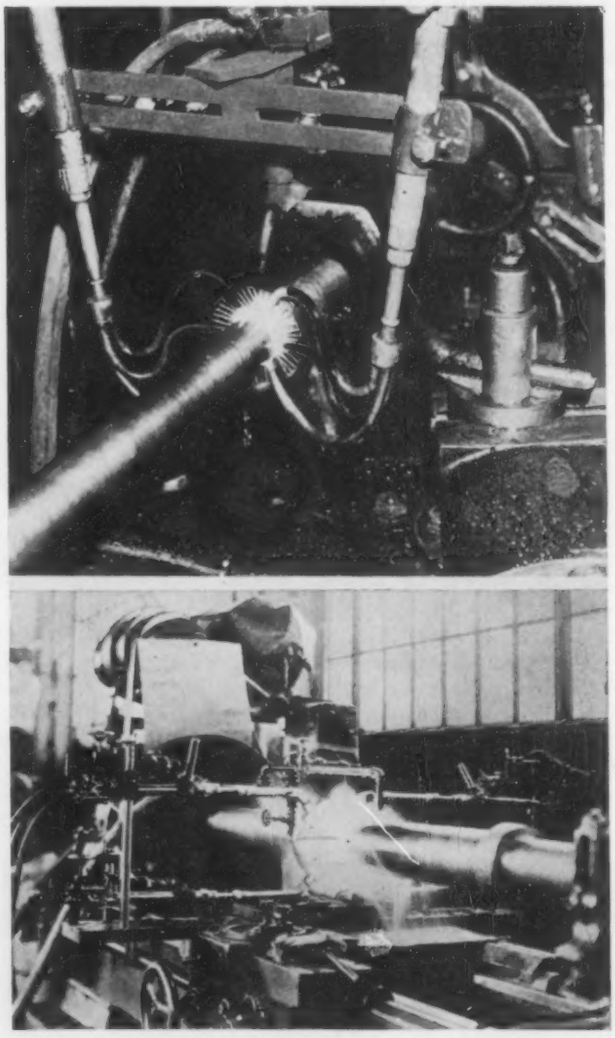


Fig. 14

Four heating tips spaced equally around this large shaft are maintained accurately in position by separate torch adjusting mechanisms. The water-quench ring follows closely behind. The most uniform hardening is obtained by the progressive spinning method, of which this is one adaptation.

in the cumulative preheating effect of the rising envelope of flame as the operation progresses. Unless this is overcome, unequal heating and variation in depth of hardness will occur, resulting in distortion. In the horizontal method the preheating effect can be more readily controlled, by a cooling stream ahead of the flames, stabilizing the preheat to a point a short distance ahead of the heated zone. Moreover, horizontal hardening is favored by length considerations, for diameters up to 10 in. Larger diameters, when hardened by the progressive spinning method, are best handled vertically because this facilitates easier control of the quenching stream.

Such distortion as does occur is governed chiefly by the condition of the metal prior to hardening. If the part is distorted before hardening, due to inherent strains, such distortion will probably increase because surface stresses induced by heating and cooling will combine with the existing stresses, tending toward increased distortion.

Normalizing and Annealing

The importance of normalizing or annealing the part to relieve stresses prior to flame hardening is well illustrated by an instance where a dozen steel rolls, 8 in. in diameter by 6 ft. long were hardened while rotating horizontally. The first two rolls were properly normalized, held in the furnace 1 hr. for each inch of diameter. Distortion after flame hardening was 0.002 in. The next two rolls were normalized for only half the time. Distortion mounted to 0.050–0.090 in. The remainder of the rolls, which had also been rushed through the furnace, were returned for proper normalizing. These rolls after flame hardening averaged 0.005-in. distortion. More satisfactory results than these cannot reasonably be expected from vertical flame hardening.

As a precaution against the subsequent development of stresses which may arise due to the surface hardness it is highly recommended that the hardened parts be stress-relieved at 400° F., to reduce surface stresses induced by the flame.

Equipment

There are various types of apparatus which may be used for specific flame-hardening applications. Selection of the most suitable type depends, first, upon the shape of the parts to be hardened, and second, upon their quantity. The shape of the objects and uniformity of hardness desired generally determine which of the four methods should be used, though these considerations together with the quantities to be hardened, enter into the decision as to selection of apparatus.

In general, the water-cooled flat hardening tips are suitable for any diameter of work, since they may be equally spaced around the circumference in whatever number is required to provide sufficient heat in a brief period of time. These flat tips, in appropriate sizes, are adaptable to any of the four methods for hardening round objects. Where quantities are large, the circular or segmental flame-hardening tips are made for the specific size of the work, using either the band or progressive spinning methods of hardening. Since these are designed to accommodate a particular diameter of work they can rarely be used for other sizes.

It is entirely practicable, however, to devise an inexpensive setup composed of several welding torch tips which will serve on small quantity jobs, provided the tips are protected from overheating by a suitable cooling jacket. This method is applicable to either the progressive spinning method or to band spinning where the band to be hardened is narrow.

Keep Your Arc Welders Welding

By R. F. Wyer*

WHILE arc-welding sets today represent the highest in simplicity and reliability, they will require periodic attention from a maintenance standpoint if they are to be kept in the best operating condition.

With the accent on production in shipyards, ordnance plants and welding shops of all types, the failure of even a few sets is sometimes costly. A systematized maintenance program will pay dividends in terms of better welder performance and longer life.

Selection and Installation

Selection

The right welding set must be selected for the job, because a maintenance program will be discouragingly difficult if misfit equipment is being used.

To insure proper choice of the rating of a single-operator set, the maximum current, load voltage and duty factor (ratio of arc time to total time) must be taken into account. Except in the smallest sizes, most sets are rated on a one-hour load. Their rating is the current which they will deliver for one hour without interruption, without exceeding a prescribed temperature rise.

Since this method of rating, chosen as a simple standard for comparison, does not take into account actual operating conditions, it is not always economically sound to choose the size next larger than the maximum operating current contemplated. However, for this same reason duty factor should be taken into account when new equipment is being considered to make certain that the set is big enough for the job.

Installation

Proper installation can do much to keep the welding equipment at work and troubles to a minimum. In wiring up a welding set, care should be taken to provide adequate branch circuit conductors, and fuse clips large enough to accommodate the necessary fuses. It should be observed that motor-generator type welding equipments have full-voltage motor starters almost without exception, so that due consideration must be given to the starting current of the motors.

Care should be taken to ground the frames of all welding equipments in order to avoid shock or annoying tickles when a grounded person touches the frame of the

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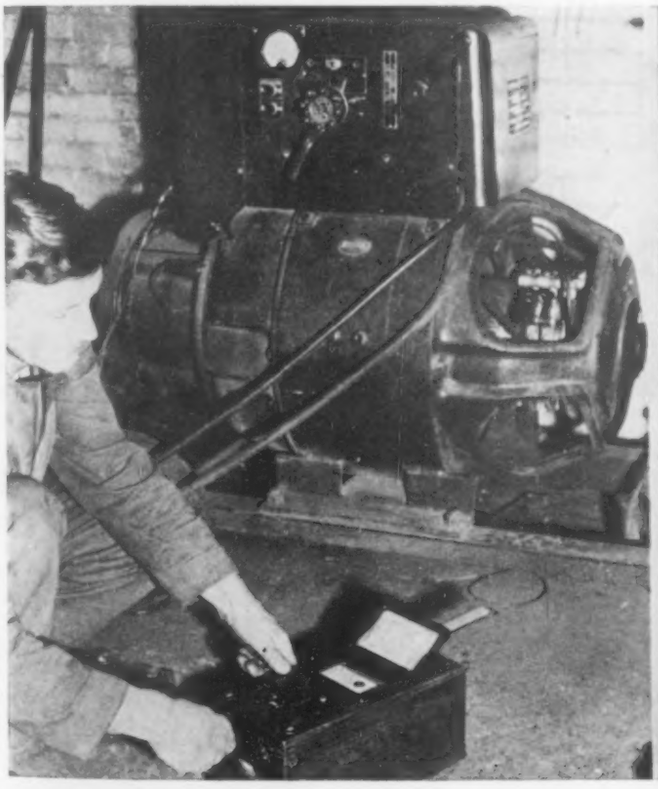
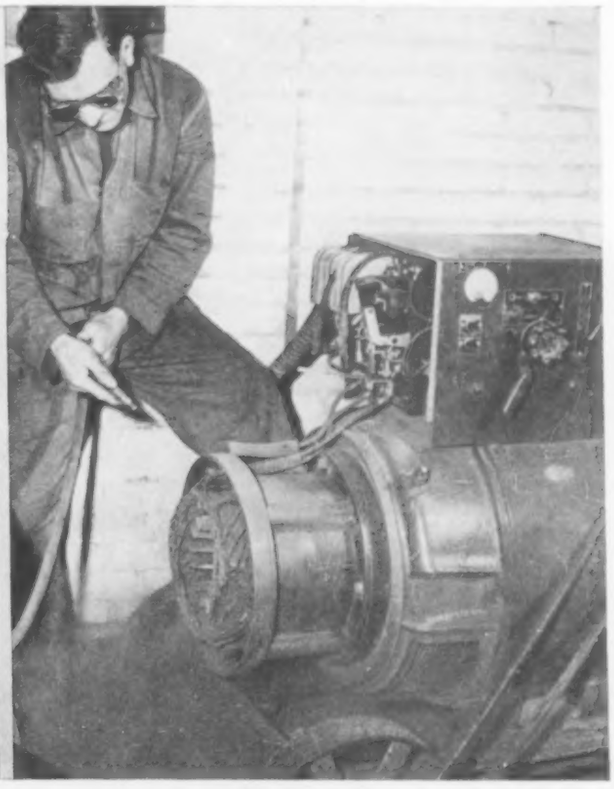


The Megger Is a Convenient Means of Determining the Condition of Insulation by Indicating Its Resistance to Leakage Currents



Blowing Dust Out of Welder Should Be Done Carefully with Low-Pressure Air to Avoid Driving Abrasive Dust Into Insulation

equipment. Even with equipment in perfect operating condition, under some conditions it is possible to receive a harmless but irritating sensation of shock from ungrounded equipment due to the passage of infinitesimal capacity or leakage currents. In addition to protecting against this annoyance, adequate grounding of machine frames is also a desirable safety precaution against harm resulting from insulation failure in equipment or leads, or improper connections.

Regardless of the type of safety ground connection which is installed, adequate low resistance work leads should always be used, and care should be taken to secure good connection between the work lead and the work. If this is not done, it is possible under some circumstances to overheat the safety ground connection by the passage of welding current through it.

In the location of welding equipment, ventilation is a very important consideration. The life of electrical insulation is seriously shortened by overheating, and overheating is bound to result where insufficient ventilation is provided. Particularly where large numbers of welding equipments are to be located in small enclosures, considerable study should be given to the problem of supplying clean, cool ventilating air. Where small houses or temporary sheds are located in hot sunshine, the heat absorbed from the sun added to the heat dissipated by the welding equipments may raise the ambient temperature above 100° F. and cause severe overheating. In such cases, large louvers or other ventilating openings should be provided in the building not only at the bottom but near the roof to give good air circulation and keep the ambient temperature below 100° F. In some instances it is desirable to provide exhaust fans to assist in removing heated air from the upper part of such enclosures.

Inspection and Regular Servicing

Records

The competent maintenance man will have a record of all welders under his care. One of the most useful and easy-to-handle references is a card file. All repair work, with its cost, can be entered on the record, and any welder requiring excessive attention or expense can be investigated and causes determined and corrected.

Inspection records will also serve as a guide to tell when welders should be replaced because of the high cost to keep them in operating condition. Misapplications, abuses and the like will also be disclosed.

Periodic Inspection

A systematic and periodic inspection of motors and generators is necessary to insure best operation. While some welders are installed where conditions are ideal—where dust, dirt and moisture are not present to an appreciable degree—most machines are located where some sort of dirt accumulates on the windings. This lowers insulation resistance and cuts down creepage distances.

Steel-mill dusts are usually highly conductive, if not abrasive, and lessen creepage distances. Other dusts are highly abrasive and actually cut the insulation in being carried through by the ventilating air. Fine cast-iron dust quickly penetrates most insulating materials

Hence the desirability of inspecting motors periodically. If conditions are extremely severe, weekly inspection and partial cleaning are desirable. Most motors require a complete overhauling and thorough cleaning about once a year.

Amp.	Speed	Make	Connection Diagram	Application	Shop or Mill No.	Card No.
Type	Motor Voltage		Time or Duty Cycle	F.L. Amp.	Phase	Cycles

Serial No. Model No.	Publication No.	Mfr's Order No. Our Order No. Date of Order Cost
BRUSHES No. Cat. No. Size Material Grade	COILS (Cat. or Spec. No.) Motor: Stator — Main, Comm., Comp.; Rotor — Coils, Bars, No. per set Generator: Field — Main, Comm., Comp.; Armature — Coils, Bars, No. per set	
BEARINGS Front End, Cat. No. Motor End, Cat. No.		User: Location:

SERVICE RECORD

Date	Shop	Floor	Service (Tacking, etc)	Duty Factor	Tested Load	
					Volts	Amps

REPAIRS

Date	Condition	Due to	Repaired by	Cost

MAINTENANCE

Greased		Inspected		Cleaned	
Date	By	Date	By	Date	By

Card Records on Every Welder in the Plant Save Time and Money. Recordings Made After Inspection and Service Indicate Any Welder Requiring Excessive Expense, and Causes Can Be Corrected Before an Emergency Occurs

Once a Week

For the weekly cleaning, the motor and generator should be blown out with dry compressed air (about 25 to 30 lb. per sq. in. in pressure). Where conducting and abrasive dusts are present, even lower pressure may be necessary, and suction is to be perferred, as damage can easily be caused by blowing the dust and metal chips into the insulation. On most motors the windings are fairly accessible, however, and the air can be properly directed to prevent such damage.

Once a Year

About once a year, welders should be overhauled. First, the heavy dirt and grease should be removed with a heavy, stiff brush, wooden or fiber scrapers, and cloths. Rifle-cleaning bristle brushes can be used in air ducts. Dry dust and dirt can be blown off, using dry compressed air at moderate pressure. Care must be taken to direct the air so that the dust will not cause damage and will not be pocketed in the various corners. Grease, oil and sticky dirt are easily removed by applying cleaning liquids such as carbon tetrachloride.

If the welder can be spared from service long enough, the insulation of the motor should be dried out by heating to from 90 to 100° C. While the motor is still warm, a high-grade insulating varnish should be applied.

The varnish may be sprayed or brushed on. After applying the varnish, the best results are obtained by baking for 6 to 7 hr. at about 100° C. If the machine must be put back into service quickly, or if facilities are not available for baking, fairly good results will be obtained by applying one of the varnishes which dry in a few hours at ordinary room temperatures.

Lubrication

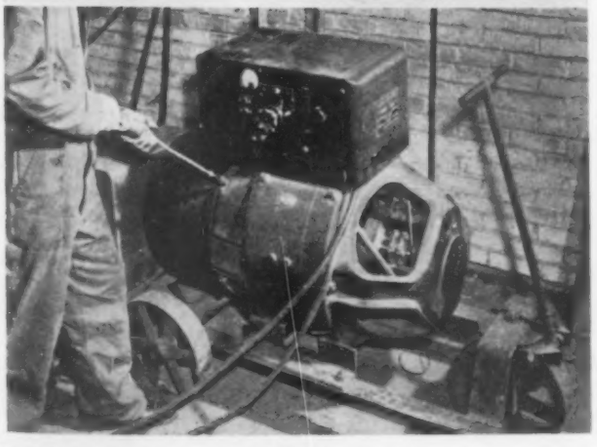
Manufacturers' instructions regarding lubrication of bearings should be carefully noted. These instructions

should be kept near the welder so that they are readily accessible. Usually grease-packed bearings have sufficient lubricant when shipped from the factory to last about a year under normal conditions of cleanliness and temperature. When sets are operated in unusually dirty atmospheres, run continuously 24 hr. per day, or exposed to extremes of temperature, it would be well to shorten the bearing inspection and lubrication interval down to six months, or less if experience warrants. An occasional check of bearing temperature by feeling with the hand may disclose undue heating before damage is actually done. Once a lubricating routine has been established, it should be carried out, and by reliable men who will follow instructions.

It is pretty generally established that outside of gross neglect for long periods of time, the major causes of bearing troubles are overgreasing and dirt. Overgreasing results in excessive heating of the bearing, frequently with churning and breaking down of the grease with consequent loss of its protective qualities.

Dirt occasionally gets into a bearing through the use of grease that is carried around or stored in uncovered containers. Quite as frequently it gets in through carelessness in protecting parts while bearings are disassembled or opened for inspection. The prevention is obvious but often overlooked:

Sanding Brushes to a Good Fit with the Commutator Is Essential Whenever New Brushes Are Installed



Hand-Operated Grease Guns Should Always Be Used on Pressure-Relief Lubricated Bearings. Grease Should Be Added Slowly to Permit Excess to Vent from Relief Pipe or Plug. (Latter not visible here.)

1. Every part of a bearing assembly, including retainer plates, gaskets and screws, should be placed in a clean box immediately on removal, and if dropped or otherwise soiled, should not be replaced without a thorough cleaning in a suitable solvent.
2. None but clean hands, tools and rags should ever be allowed to touch a bearing.
3. Grease *must* be clean. If there is the slightest doubt of its purity, it should be thrown away. Grease is cheap compared with bearings and lost man-hours.

Only a high grade of grease should be used for ball-bearing lubrication.

Brushes

Brush inspection is important. The first essential requirement for the satisfactory operation of brushes is the free movement of the brushes in their holders. Uniform brush pressure also is necessary to assure equal current distribution. Adjustment of brush holders should be set so that the face of the holder is approximately $^1/_8$ in. up from the commutator; any distance greater than $^1/_8$ in. may cause brushes to wedge, resulting in chattering and excessive sparking.

It is essential that the correct grade of brush for a specific application be used. Recommendations as to the correct grade of brush should be obtained from the manufacturer of the welder only.

Broken brushes imply two possibilities: incorrect brush grade or mechanical defects (such as unbalanced, rough or eccentric commutator). To eliminate brush breakage, both factors should be corrected.

Check the brushes to make sure that they will not wear down too far before the next inspection. Keep extra sets of brushes available so that replacement can be made when needed. It is false economy to use brushes down to the absolute minimum length before replacement. Cases have been known where brushes have worn down until the metal, where the pigtail connects to the brush was touching the commutator. This, of course, was causing damage to the commutator.

Make sure that each brush surface, in contact with the commutator, has the polished finish that indicates good contact, and that the polish covers all of the surface of the brush. When replacing a brush be sure to put it in the same brush holder and in its original position. It has been found helpful to scratch a mark on one side of the brush when removing it, so that it will be replaced properly.

When installing new brushes, fit them carefully to the commutator. Sand only until the curve of the brushes is the same as that of the commutator. Be sure that the brush shunts (pigtails) are fastened securely so that current will not overheat the brushes and brush holders.

Check the springs that hold the brushes against the commutator. Improper spring pressure may lead to commutator wear and excessive sparking. Excessive heating may have annealed the springs, in which case they should be replaced and the cause of heating corrected.

Commutators

Inspect the commutator for color and condition. It should be clean, smooth and glossy, with a color varying from straw to chocolate-brown where the brushes ride on it. A bluish or reddish color indicates overheating of the commutator. Roughness of the commutator should be removed by sandpapering or stoning. Never use emery cloth or an emery stone. Use a "fine" stone or

number 00 sandpaper unless the commutator is in bad condition, when the job may be started with a "coarse" stone and finished with "fine."

For this operation, press the stone or sandpaper against the commutator with moderate pressure with the motor running, and move it back and forth across the commutator surface. Use care not to come in contact with live parts. Be sure to keep the dust out of the machine.

If the commutator is very rough as evidenced by pronounced up and down vibration of the brushes, the armature should be taken out and the commutator turned down in a lathe. When this is done, it is usually necessary also to cut back the insulation between the commutator bars slightly. If the commutator is found to be dirty when the generator is inspected, it should be wiped clean with a piece of canvas or other cloth that is free from lint.

Never put oil on the commutator. Proper selection of brushes gives the commutator all the lubrication required to prevent excessive wear and to build up a good smooth operating glazed surface on the copper. The addition of oil results in the development of a high resistance film which may cause undue heating and rough brush action. The oil will also have a detrimental effect on the internal parts of the commutator.

Transformers

The arc-welding transformers of alternating-current welders require a minimum of maintenance, but this fact should not be allowed to result in neglect. On fan-cooled units, fans should be cleaned and lubricated about once a year. Windings should be blown out at least twice a year in very clean locations, and more often in dusty places. At the time of this periodic attention, all connections and coil supports should be checked for tightness. Manual current adjusting mechanisms should be lubricated often enough to prevent stiff operation of the handwheel or crank, making sure that a fairly high melting-point grease is uniformly distributed over the full length of screws and guides. On motor-operated controls, lubrication at more frequent intervals may be required, as evidenced by slowing down of the motor or noise from the gearing. This point should be checked at least three times a year, and more often if experience justifies it.

Abuses

While most welding equipment is designed to stand up under unusually adverse operating conditions, some not infrequent circumstances will cause serious impairment if not complete interruptions of their service.

One bad practice, for example, is that of leaving weather-protecting tarpaulins thrown over machines in operation, in such a way as to interfere with the free passage of ventilating air into and out of the equipment. Cases are known where welders have been equipped with canvas flaps permanently installed on inlet and exhaust air openings, resulting in severe overheating and very short equipment life.

Improper connection of extension leads for either the electrode or work terminals is not at all uncommon. This results in a high resistance circuit from welder to arc and return with resulting variations in welding current, particularly when the leads are moved so as to change the resistance of the connections. This is a frequent cause of complaints by welding operators that the heat is not steady. The remedy for this is to make sure that connections are kept tight, and that all connections

Picture Showing Welders Working on a Huge Motor Frame in a Large Eastern Plant

are made with cables equipped with properly installed cable lugs or terminals. It is practically impossible to bolt or wedge untinned flexible cable to another conductor and secure a good low-resistance joint. Soldered or reliable solderless connectors or terminals should always be used.

The use of excessively long electrode or work leads with motor-generator type welders will result in overheating of the motor when operating in the upper part of the current range unless extraordinarily large cables, or a number connected in parallel, are used. Overheating of the motor from this cause is a frequent reason for motor-generator welders tripping off the line with consequent loss of production.

A source of trouble which is not protected against by the motor overload relays is the intentional or unintentional application of long-continued short circuits on the generator. Poor cable or cable connection insulation may be responsible for unintentionally short circuiting a generator for long periods of time. This results in the flow of very heavy generator current, but, because of the low generator voltage involved, does not require sufficient power input from the line to cause the motor overload relay to trip. While the motor is not damaged, the generator may be seriously overheated or burned out. The same results will follow intentional permanent short circuiting of the electrode holder on the work or any grounded conductors.

The use of improperly bonded structural steel systems or building frameworks for the welding current return circuit is undesirable. The high resistance path thus afforded the welding current may result in overheating of the welder motor and, in addition, there is always the possibility that arcing or overheating of some poor connection, possibly quite remote from the scene of operations, may go unnoticed and start a fire.

No attempt should be made to adjust welding current output by any means other than those provided and recommended by the manufacturer of the equipment. Shifting the brushes on generators not designed for brush-shifting control will usually result in inferior welding characteristics, impaired commutation and short brush life. Short circuiting of resistors or rheostats or any other tampering with the control furnished on arc-welding equipment may result in damaging or burning out the equipment.

In transporting welding equipment, rough handling resulting in permanent mechanical damage is all too frequent. Motor-generator sets mounted on steel wheeled running gear should be moved only at slow speeds—never behind fast-moving trucks or other vehicles. They should be eased over obstacles and depressions such as flange clearance grooves in tracks. Slings used for transportation of welders by crane should

be carefully arranged to avoid damaging control boxes, handles and other equipment mounted on the outside of the set.

Care should be taken to avoid using arc welders out-of-doors in unfavorable weather. Many machines now on the market are designed to be both semi-protected and drip-proof. This does not mean, however, that these welders should be used in rain or other precipitation without suitable protection.

At the discretion of the user, of course, drip-proof or even open motor-generator sets can be operated out-of-doors, provided they are protected from obviously damaging conditions by tarpaulins or temporary shelters. These must be arranged so as not to hinder ventilation of the equipment, as previously discussed.

Common Troubles and Their Remedies

In spite of the reliability of the modern arc welder, troubles will occur. The causes and remedies for the majority of such troubles are given in the following tabulation.

Trouble	Causes	What to Do
Machine fails to hold heat	Rough or dirty commutator	Commutator should be trued or cleaned
	Brushes may be worn down to limit of adjustment or life	Replace or readjust brushes
	Brush springs may have lost adjustment or may be broken	Replace or readjust brush springs
	Field circuit may have variable resistance connection or intermittent open circuit	Check field current with ammeter to discover varying current. This applies to both the main generator and exciter if used
	Electrode lead or work lead connections may be poor	Tighten all connections
	Wrong grade of brushes may have been installed on generators	Check with manufacturer's recommendations
	Field rheostat or tap switches may be making poor contact and overheating	Inspect rheostat and clean and adjust finger tension on switches
	Brush-shifting or other mechanical current-adjusting mechanism may have loose or worn links	Check current-adjusting mechanism for backlash and play
Motor trips off line	Power circuit may be single-phased	Check for one blown fuse or dead line
	Welder may be operating above current capacity	Check load against welder nameplate
		Check duty cycle
	Welding electrode or work leads may be too long or too small in cross section	Check terminal voltage while machine is loaded; it should not exceed 30 volts on small machines or 40 volts on large machines when operating at rated current
	Ambient temperature may be too high	Make sure that temperature in motor-generator room or housing does not exceed 100° F. and that there is no interference with normal ventilation of the machine
Machine fails to start	Power circuit may be completely dead	Look for open disconnect switch, fuses removed from clips, or blown fuses
	Power circuit may be single-phased	Look for one blown fuse or one dead line
	Power line voltage may not be suitable for motor, or may be extremely low; may be accompanied by chattering of the motor starter	Check voltage with voltmeter, particularly at the moment of attempted starting
	Machine may be jammed	See that armature turns over easily by hand, and look for foreign material in air gaps
	Motor starter may be single-phased	Check to see that all fingers on starter make contact when closed
	Overload protecting relays may be tripped	See that relay contacts are closed and that starter picks up when push button is pressed. Be sure to remove cause of tripping
Welder starts but fails to generate	May be running the wrong way	Check direction of rotation with manufacturer's instructions or direction arrow. On 3-phase motors, direction of rotation may be changed by interchanging any two leads
	Generator or exciter brushes may be loose or missing	Be sure that all brushes bear on the commutator and have proper spring tension
	Exciter may not be operating	Check exciter output voltage with voltmeter or lamp
	Field circuit of generator or exciter may be open	Check for open circuits in rheostat, field leads and field coils. Also check resistors and rectifiers, if any. Some machines give low output when fields are open
	Generator may be reversed in polarity due to another machine or incorrect operation in parallel with another machine	*Flash the field with a storage battery or another generator first with one polarity and then with the other to see if it builds up. (Flash exciter field if set has separate exciter)
	Series field and armature circuit may be open-circuited	Check circuit with ringer or voltmeter
Welding arc is loud and spatters excessively	Current setting may be too high	Check setting and current output with ammeter
	Polarity may be wrong	Check polarity
		Try reversing polarity or try an electrode of the opposite polarity

* "Flashing" the field of a generator or exciter is a method of establishing the residual magnetism of the field structure with the proper polarity to cause the machine to "build-up," or generate voltage. It consists of passing a relatively heavy current through the field windings momentarily, using an external source of direct current to supply the power.

If a low-voltage source, such as a storage battery, is used, the series field of the generator should be flashed; if a higher voltage source such as another generator or exciter is used, the shunt field should be flashed.

Voltage Variation Tolerance for A.C. Resistance Welding

By L. G. Levoy*

Introduction

THE purpose of this article is to acquaint electrical distribution system designers and welding engineers with the voltage regulation and voltage variation requirements for A.C. resistance welding equipment.

Theoretically, the allowable voltage variation should be prescribed by the welding engineer. The individual who is responsible for establishing these limits should not only be thoroughly familiar with welding requirements but also should be familiar with practical regulation limits, and should know what is involved in improving regulation beyond the usual values obtained. It is of no assistance to the system designer to request either "no regulation" or "regulation as good as possible."

The most economical design can only be made when the system designer is informed concerning (1) the maximum voltage variation which can be tolerated and (2) the value of improved regulation to the user. While the electrical distribution system designer is not expected to be a resistance welding specialist, nevertheless he is frequently consulted for advice and guidance in the choice of permissible voltage variation. It is hoped that this article will provide a rational basis for establishing this elusive quantity.

Unfortunately, no uniform standards have been established to date. The ultimate criteria for acceptable regulation and/or voltage variation are weld quality, in so far as the requirements for resistance welding are concerned. It should be recognized, however, that light flicker and interference with other equipment on the system may, in some cases, require considerably more rigid tolerances than are imposed by the welding requirements alone. The discussion of these other requirements and limitations have been adequately treated elsewhere and are not considered in this article.

Definitions

The following quantites are defined for convenience in this study:

1. *Voltage Regulation* (of bus or feeder, including source).

$$\% \, VR = \frac{V_{NL} - V_{RL}}{V_R} \times 100$$

where

$\% \, VR$ = per cent voltage regulation of circuit at point under consideration.
V_{NL} = no load voltage.
V_{RL} = voltage when normal rated load is applied. This will vary with the power factor of the load.
V_R = rated voltage of feeder.

2. *Voltage Drop* (of bus or feeder, including source).

$$\% \, VD = \frac{V_{NL} - V_L}{V_{NL}} \times 100$$

where

$\% \, VD$ = per cent voltage drop of circuit at point under consideration when load L is imposed on it.
V_{NL} = no load voltage of bus or feeder.
V_L = voltage of bus or feeder when load L is connected. This will vary with the magnitude and power factor of the load.

This definition of voltage drop is desirable because the definition of voltage regulation refers to rated load conditions. In resistance welding practice, the instantaneous demand may exceed the continuous feeder rating by several times (without exceeding its thermal rating) due to the low duty cycle. Under these conditions the "voltage drop" defined under (2) is more useful, since L can be any load and therefore it may be taken as the welding demand load.

3. *Voltage Variation* (of bus or feeder, including source, at the last branch point from which the welder is independently fed).

$$\% \, VV = \pm \frac{{}^1/_2(V_{max.} - V_{min.})}{{}^1/_2 \, (V_{max.} + V_{min.})} \times 100$$

where

$\% \, VV$ = per cent voltage variation of the circuit at the point under consideration.
$V_{max.}$ = maximum voltage of circuit at point under consideration.
$V_{min.}$ = minimum voltage of circuit at point under consideration exclusive of any drop caused by operation of the particular welder whose voltage variation is being studied.

The preceding three definitions represent circuit characteristics. The following two definitions represent characteristics of the weld.

4. *Current Tolerance* (of resistance weld).

$$\% \, CT = \pm \frac{{}^1/_2(I_{max.} - I_{min.})}{{}^1/_2(I_{max.} + I_{min.})} \times 100$$

where

$\% \, CT$ = current tolerance in per cent (based on the average value) which can be allowed in making a given resistance weld and still maintain the weld quality within acceptable limits, when no other changes are made.
$I_{max.}$ = maximum acceptable value of current.
$I_{min.}$ = minimum acceptable value of current.

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5. *Voltage Tolerance* (of resistance weld).

$$\% \ VT = \pm \frac{\frac{1}{2}(V_{max.} - V_{min.})}{\frac{1}{2}(V_{max.} + V_{min.})} \times 100$$

where

$\% \ VT$ = voltage tolerance in per cent (based on the average value) which can be allowed on the primary terminals of a resistance welding transformer and still maintain the weld quality within acceptable limits, when no other changes are made.

$V_{max.}$ = maximum acceptable value of voltage at primary terminals of welding machine.

$V_{min.}$ = minimum acceptable value of voltage at primary terminals of welding machine.

A comparison of (4) and (5) indicates that, when the circuits are substantially linear, the voltage tolerance and current tolerances are equal. This condition is closely approximated where the apparatus is correctly designed.

These definitions of current and voltage tolerance represent what might be obtained under ideal laboratory conditions where all other factors are carefully controlled, and can be maintained constant. In practical welding operations, certain allowance must be made for variations in material, surface condition, electrode size and other variables, so that the permissible voltage tolerance is usually much less than that found for ideal conditions. This phase of the problem will be considered later under "Interpretation of Results."

Weld Quality

Since weld quality is the criterion which determines the permissible voltage variation at the terminals of the welding machine, it is desirable to list the qualities for which a weld may be rejected, and also some of the factors which influence weld quality.

Welds may be considered unsatisfactory for any one or any combination of the following reasons:

1. Lack of strength, ductility or other physical properties.
2. Appearance—indentation and surface marking.
3. Lack of corrosion resistance.
4. Porosity in weld.
5. Cracks in weld.
6. Flash—metal extruded from joint or surface.
7. Deformation of parts being welded—warping.
8. Leaks through weld (in pressure or vacuum vessels).

Weld quality is dependent upon a host of factors in addition to voltage variation requirements. This fact must be recognized by the system designer as well as the welding engineer if a permissible range of voltage variation for any given case is to be selected for a system which will produce a certain weld quality in specific materials, on a given number of machines, and possibly with certain other specified conditions.

Some of the factors which may cause poor weld quality, even if proper voltage and current are available, are:

1. Poor material—composition and structure.
2. Surface condition—type of cleaning used.
3. Improper design of welded joint.
4. Improper pressure on electrodes.
5. Electrode material and conditions.
6. Erratic friction in welding machine head.
7. Lack of follow-up due to inertia of machine head.
8. Improper setup.
9. Inaccuracy of manufacture of parts to be welded.
10. Improper cooling of electrodes and transformer.
11. Improper control operation.
12. Proximity of other welds.

This list is by no means complete. However, it will serve for illustrative purposes. Any one of these factors can cause a defective weld or reject if its deviation from the requirements is sufficiently great. Defective work may also result from a combination of several of these factors, any one of which existing alone may be satisfactory.

We are now in a position to understand why there is so much difference of opinion and difference in field practice concerning this matter.

The factors already mentioned are capable of influencing the quality of the weld all the way from perfect welds to rejects with perfectly normal voltage conditions. From this it is evident that the degree of control exercised over these quantities will establish how much latitude is left for voltage variation while maintaining the desired weld quality.

Experience has shown that all of these quantities can be maintained within reasonably close limits by good supervision.

The Effect of Voltage Variation

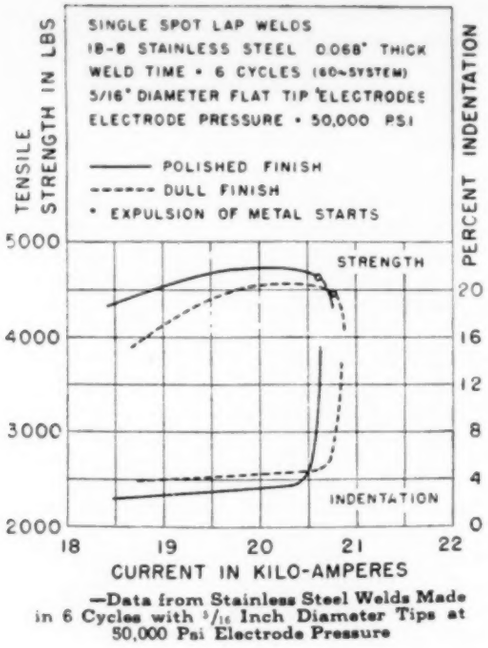
The principal effect of voltage variation on the primary terminals of a resistance welding machine is to influence the secondary welding current.

The rate of generation of heat in a resistance weld is proportional to the square of the welding current, consequently current is the important function. However, since the circuits are essentially linear the current is proportional to the voltage. The "current variation tolerance" of the weld is therefore equal to the "voltage variation tolerance" at the primary terminals of the welding transformer.

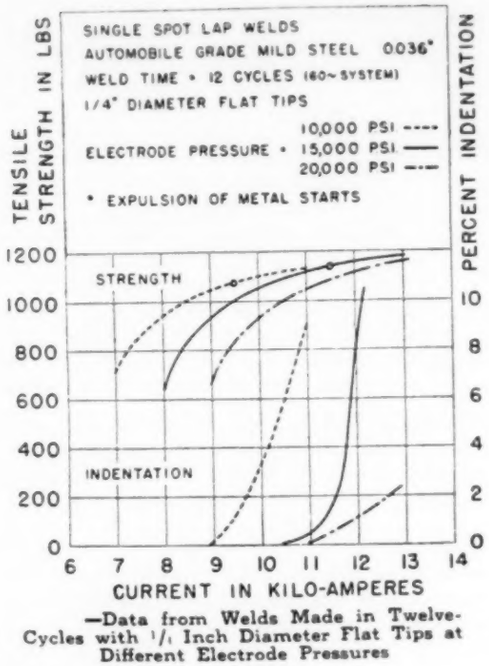
The voltage variation tolerance has already been defined as the limiting range of voltage which can be applied to the primary terminals of the welding transformer, on any spot or group of spots, and produce a satisfactory weld without any other change in the welding machine, setup, electrodes, material, or control adjustment.

The voltage variation, important from the standpoint of weld quality, is the variation in terminal voltage on the welding transformer primary terminals which may exist during operation on any weld or group of welds. It is evident that any fixed voltage drops incurred by the operation of the welding machine itself (such as voltage drop in the last feeder which independently serves the welding machine, and increments of drop throughout the remainder of the system caused by this load) will have no influence on the voltage variation. These drops are always present and consequently the initial adjustment of the machine compensates for them. They do, of course, influence both regulation and voltage drop at the machine terminals. System voltage drops caused by other machines must always be considered.

To establish the effect of voltage variation, it is necessary to investigate the results obtained by holding all of the other conditions essentially constant and changing the welding current. Since the circuits are substantially linear, the change in welding current can be interpreted directly as variation in welding voltage available at the welding machine.



—Data from Stainless Steel Welds Made in 6 Cycles with 5/16 Inch Diameter Tips at 50,000 Psi Electrode Pressure



—Data from Welds Made in Twelve-Cycles with 1/4 Inch Diameter Flat Tips at Different Electrode Pressures

Figs. 1 and 2—(Reproduced from The Welding Journal, Oct. 1939)

The Effects of Current Variation

Since the influence of current variation on the weld quality varies with the material, pressure, spot diameter, thickness and duration of current flow (spot length), it is necessary to examine specific cases, holding all variables constant except the one under consideration, which in this case is weld current. Little data of this nature are available at the present time. Fortunately, however, some of the more common materials have been studied and it is probable that much more data will be taken within the next few years.

Some typical strength-current and surface indentation curves are shown in Figs. 1 and 2.

More information of this character has been published:

Material	Reference
Stainless steel	The Welding Journal, Oct., 1938, p. 42-s
Aluminum	" " " Nov., 1938, p. 50-s
Mild steel (automobile grade)	" " " Oct., 1939, p. 329-s
Mild steel and stainless steel	" " " Oct., 1939, p. 349-s
Annealed mild steel	" " " Apr., 1939, p. 114-s
Alclad	" " " July, 1940, p. 259-s

Observation of the strength-current and indentation characteristics of resistance spot welds reveals the following general characteristics:

1. As the welding current is increased above the value where welding first begins, there is a rapid increase in spot strength which continues with a diminishing rate up to a certain limit beyond which the strength diminishes. (Not all the curves were carried out to this point.)
2. As the current increases, the indentation increases at an increasing rate.

The undesirable characteristics exhibited by welds when the current exceeds acceptable limits are as follows:

Too Hot (too much current)	Too Cold (too little current)
Stainless Steel	
Carbide precipitation	Failure to weld
Loss of stainless qualities	Low strength
Bad surface marking	Small diameter of weld
Voids in weld	
Distortion of work	
Low strength	
Short electrode life	
Aluminum	
Blowholes and cracks in weld	Failure to weld
Bad surface marking	Low strength
Low electrode life	Small diameter of weld
Pick-up of material on electrodes	
Low strength	
Distortion of work	
Mild Steel	
Porosity in weld	Failure to weld
Burned weld	Low strength
Low shear strength	Small diameter of weld
Bad surface marking	
Low electrode life	
High electrode maintenance	
Distortion of work	

From these curves and weld characteristics it appears that the minimum acceptable value of current (for making a resistance weld with all other conditions fixed) is usually determined by the minimum weld strength which is acceptable.

The maximum current which is acceptable may also be limited by weld strength, surface marking or by any one of the other characteristics listed for welds which are overheated.

Interpretation of Results

Because of the wide variations in materials, welding conditions and quality requirements encountered in practice the permissible voltage variation tolerance will vary with the particular circumstances.

For example, consider the welding of two pieces of polished stainless steel under the conditions shown in Fig. 1. Let us further assume that the minimum acceptable spot strength for this application is 4500 lb., the maximum permissible indentation is 5% and that no other criteria of weld quality are to be applied. Under these conditions Fig. 1 indicates that the welding current can range from a minimum of 18,800 amp. to a maximum of 20,500 amp. or a variation of plus or minus $4^1/_2$% from the average with all other conditions maintained ideal.

As a practical matter it is not usually possible to maintain all of the other conditions ideal so that it would be desirable to limit the voltage variation to a smaller value to permit some latitude in other conditions which influence weld quality.

As another example, consider the welding of automobile grade mild steel 0.036 in. thick using an electrode pressure of 15,000 psi. and with other conditions shown in Fig. 2. Assume that the indentation must not exceed 5%, the spot strength must not go below 1000 lb., and that no "flash" or expulsion of metal from the weld can be tolerated.

In this case the maximum current is limited by expulsion of metal to 11,500 amps. The minimum current required to give the specified strength is 9500 amp. or a current range of approximately plus or minus $9^1/_2$% from average.

Here again it would be necessary in practice to limit the voltage variation to a smaller range to permit some variation in departure of other conditions from the ideal. The uniformity of material, its surface condition, the permissible reject rate and other factors already mentioned will determine how much this figure must reduce in any given case.

As a practical matter, with reasonably good inspection and material requirements, it is usually possible to make good welds if the voltage variation tolerance is maintained within half of that permissible under ideal conditions. This figure will of course vary with the conditions in the particular plant under consideration.

It is apparent that the permissible voltage variation depends upon the following factors

1. Material to be welded.
2. Control of material (uniformity).
3. Welding conditions.
4. Control of welding conditions (uniformity).
5. Weld quality requirements.

Until these factors are specified within reasonable limits, the voltage variation tolerance cannot be established.

One of the most satisfactory ways to establish the tolerance limits of any particular material is to make up test welds under the proposed welding conditions. The influence of current variation and range of other variables likely to be encountered can then be studied.

In practice it is always desirable not only to keep the voltage variation tolerance below that required, but to minimize it as much as is practical to permit the maximum latitude in other conditions.

Voltage Regulation and Voltage Drop

Up to this point the requirements of the weld alone have been considered. However, it is essential that the control operate correctly. Most electronic welding controls will operate satisfactorily over a plus or minus 5% voltage range and will tolerate short dips of voltage of 10%. When these limits are exceeded some controls may not give consistent operation. When this is the limiting factor, it is usually possible to run the control wires further back in the circuit or otherwise arrange to obtain a more suitable source of control power.

Voltage Regulation and Voltage Variation

The term voltage regulation is sometimes loosely used to mean voltage drop. However, neither the voltage regulation nor the voltage drop bears any fixed relation to voltage variation or voltage tolerance (refer to "Definitions").

Voltage Tolerance for Spot, Seam, Projection, Butt and Flash Welds

Up to this point we have been primarily concerned with spot welding. However, several other types of welding come under the general classification of resistance welding.

Seam Welding

Experience has indicated that for gas-tight seam welding jobs, the practical voltage tolerance is somewhat less than for spot welding of the same material. The reason for this is that a gas-tight seam weld consists of a series of overlapping spot welds, and any one piece of work may contain several thousand such spots. A small decrease in current during one spot may cause the spot or zone of fusion to decrease in diameter to the point where overlap does not occur, yet the spot may be strong enough from a mechanical standpoint. Under these conditions a leak may exist in the seam. Because of the relatively large number of individual spots in a seam, and since a defect in one spot may cause the entire piece to be defective, the reject rate for seam welding under the same voltage variation conditions is apt to be higher than for spot welding. Or, in other words, to obtain the same reject rate, voltage variation must be further reduced for gastight seam welding. Some data indicating this is given under the heading of "Field Experience."

Projection Welding

In projection welding, the projections act essentially as a new electrode for each spot; consequently it is unnecessary to allow for "mushrooming" of the electrodes as is the case with spot welding. For this reason, practical voltage tolerance may be increased.

Butt and Flash Welding

Butt and flash welding fall in about the same class as projection welding in so far as voltage tolerance is concerned.

Making Resistance Welds Under Adverse Voltage Conditions

This study would not be complete without accounting for the large amount of resistance welding now being accomplished under relatively poor voltage conditions.

In many such cases the reject rate is high and the weld quality low. It is possible, however, to produce acceptable welds under adverse voltage conditions.

The writer has personally witnessed several of these

cases. Frequently the system designer is confronted with examples of this nature when he is attempting to guide the customer in providing an adequate distribution system. For this reason a few examples are given where welding was actually being done on a commercial scale.

Example 1.—A certain manufacturer was welding aluminum using synchronous control adjusted for very short spot length. The voltage drop at the machine terminals (and on the control) was 60%—that is, the voltage dropped from 550 down to 220 volts. Only one welding machine was operated on this feeder and consequently acceptable welds were being made most of the time. The customer complained of short tube life and occasional erratic operation of the control.

Example 2.—A certain manufacturer was seam welding mild steel, using synchronous control of a type which maintains its calibration even on greatly reduced voltage. He complained of short tube life, high reject rate and poor electrode life. Investigation revealed that the voltage drop was about 40% per machine, and when two machines overlapped on the same phase, the voltage dropped 57%. The reject rate was about 10%, part of which could be saved by rewelding. Most of the welds appeared badly burned. The appearance did not concern this manufacturer, however; he was concerned over the short tube life and large rework rate which was a direct loss to him.

In this case the regulation was improved and the cost of the change was saved in less than one year by the diminished reject and rework rates.

In sharp contrast with this, the General Electric Co., welding a similar product, has a reject rate of 0.1% due to welding. This is accomplished by maintaining the voltage within ±3% at all times, together with accurate control of all other conditions which influence weld quality.

Example 3.—A small foot-operated, non-synchronous, manually timed welding machining was used for welding mild sheet steel. The operator would judge the weld time by observing the color. It was found that an experienced operator could make reasonably good welds with a range of voltage variation of about 50%, although the amount of discoloration and indentation varied over a wide range.

These examples would not be considered as satisfactory welding from the standpoint of modern high-speed production. They are cited to prevent the system designer from getting the idea that it is impossible to make welds under adverse voltage conditions. It is not impossible, but it is far from desirable.

There are several means of improving the situation when the voltage variation is in excess of that required for good welding. Some of these are as follows:

1. Electrically interlock large spot welding machines located on a single feeder so that they will not come on simultaneously. This expedient frequently helps the voltage condition without appreciable interference with production, since the duty cycles are usually low.
2. Schedule heavy welding work at a time when it will not interfere with other work.
3. "Overwelding" is resorted to in many plants where voltage conditions are uncertain. For example, if a piece required two good spot welds to give it the required strength and safety factors, some manufacturers will put six or more welds on it, so that if one or two welds are defective, the piece is still sufficiently strong to pass inspection and test.
4. When welding material which has considerable latitude, the welding machine is adjusted for the maximum permissible current at maximum available voltage even though this burns the welds slightly. Under these conditions a lower voltage may be acceptable without producing rejects than would be the case if the machine were set to produce the best weld under the average voltage condition.
5. When the voltage swings are relatively slow, the operator can make compensating adjustments on the welding machine or control.
6. Voltage compensated controls can be used which automatically adjust themselves (for changes in voltage within certain limits) to maintain constant current to the weld.
7. Ampere squared second recorders can be used to signal the operator when the product of current squared and time deviates from the normal value by more than a predetermined amount.
8. Greater tolerance in system voltage variation can be allowed by greater accuracy in control of conditions, thereby approaching ideal conditions more closely. Thus more frequent changes in electrodes are required to maintain weld quality in a plant where poor voltage conditions prevail, than in a plant where good voltage conditions exist. Likewise greater variation in other conditions can exist with good voltage, and still maintain weld quality as compared with the plant having poor voltage conditions.
9. Certain types of energy storage controls are equipped with devices which automatically limit the energy to a pre-set level regardless of the supply voltage variation within certain limits.

Procedure When Voltage Tolerance Is Unknown

Since practical operating conditions play such an important part in establishing the range of acceptable voltage variation, one of the most satisfactory ways to determine it is to study the layout and welding conditions in other plants welding similar products, and determine their voltage variation limits.

Several typical plant layouts have been published. It is believed that most of the plants covered in these studies were welding steel.**

In cases where the material and welding conditions are similar to those for which the welding characteristics are already available, this information combined with the welding condition, material control and weld quality requirements will enable the designer to estimate the voltage variation which can be permitted.

Where the material or product or both are new, and nothing is known concerning the voltage variation tolerances, it is recommended that test specimens be welded to explore the acceptable range of voltage variation. In this way voltage variation limits can be established for acceptable weld quality with practical control of material and welding conditions.

Procedure When Prescribed Voltage Limits Result in Excessive Cost of System

In order to realize minimum voltage variation, system designers frequently make use of some of the following devices:

1. Low reactance supply transformers.
2. Interlaced or concentric bus runs.
3. Location of machines and transformers to provide shortest possible connections.
4. Power-factor correction of machines.
5. Interlocking of large machines to prevent simultaneous operation.
6. Use of energy storage type welders.

In event the cost of the systems required to provide the prescribed voltage limits becomes excessive, the user can either accept a wider range of voltage by using some of the expedients listed under "Making Resistance Welds Under Adverse Voltage Conditions" or accept a lower standard of weld quality or increased reject rate, or both.

Nameplate Ratings of Resistance Welding Machines

In laying out a system to serve resistance welding machines, it is important that the actual demand of the welding machines be known. At the present time, the nameplate ratings are based on a 50% duty cycle. That is, a transformer having 100-kva. nameplate rating may operate within its rated temperature rise under any one of the following conditions:

Demand Kva.	Duty Cycle, %
70.7	100
100	50
141	25
224	10
315	5
447	2.5

From this table it is evident that the present name-plate rating bears no relation to the demand and consequently it is essential to obtain the actual demand rather than the name-plate rating. These data can generally be obtained from the resistance welding machine manufacturer.

In laying out the distribution system it is important that all feeders, transformers, etc., be checked not only from the standpoint of voltage drop limitations but also from the standpoint of thermal rating.**

Field Experience

Several companies doing large amounts of resistance welding were contacted to obtain data concerning their voltage conditions. These are listed below:

1. General Electric Co., New York State plant: In the seam welding of stainless steel evaporators, plus or minus 3% difference of voltage was found to give practically perfect results. Plus or minus 5% gives fair welding conditions but reject rate is increased. Plus or minus 7% gives very definite trouble and large rate of rejects. These measurements were made with a recording voltmeter.
2. General Electric Co., Pennsylvania plant: Spot and seam welding of mild steel refrigerator cabinets. In this plant, 5% drop in bus voltage as measured with a recording meter is the maximum which they consider desirable. Oscilloscopic observation reveals instantaneous drops up to 10%.
3. Most of the automobile plants around Detroit were designed for about 10% maximum instantaneous drop at the last distribution point when the largest machine was energized. Most of these plants were welding ordinary body steel where extremely precise results are not required.

The distribution of voltage drop is of interest to the system designer. This information has also been published for several typical plants.**

No single maximum value of voltage regulation, voltage drop or voltage variation tolerance can be given which will cover all cases. Sometimes satisafctory results may be obtained with 15% regulation in one case and 5% may be too much in another.

Field experience indicates that with the usual class of production resistance spot welding involving low and medium carbon steels, satisfactory welding will result if the voltage drop on the supply system common to two or more machines does not exceed 10% for the largest machine of the group. This statement is based on the assumption that there are relatively few large machines in the group being served (say not over six machines) and that while two of them may occasionally operate at the same time, the chances of three or more operating together is extremely remote. Thus, if the machines were adjusted for perfect welding with 10% voltage drop in their supply circuit, the welds would still be good when two machines operate together causing nearly 20% drop (assuming a minimum of ±5% voltage variation tolerance in the weld). If three or more machines happen to hit together, poor welds or rejects may result. Care should be exercised in adjusting the machines with the settings made under the highest voltage and maximum current conditions, just short of burning the weld so that under minimum voltage conditions a good weld will still result.

Experience indicates that this general rule of 10% drop for the largest machine (under conditions previously described) will result in a good workable installation in most cases, although it should be realized there will be exceptions.

If, at equal cost, less than 10% regulation can be provided by close spacing of the feeders, etc., this obviously should be done. The 10% figure is set only as an approximate allowable upper limit and any improvement below this value is all to the good and makes for that much better welding conditions.

Interlocking can be resorted to under some conditions to insure not more than one or two machines operating at the same time. This is an inexpensive practice where only a few large machines are involved and in most cases production speed is not materially reduced.

Conclusions

1. No single maximum value of voltage regulation, voltage drop, voltage variation or voltage tolerance can be given which will cover all cases. Satisfactory results may be obtained with 15% regulation in one case and 5% may be too much in another.
2. The 10% rule given under the heading of "Field Experience" has been frequently used as a guide for installations for the production welding of low and medium carbon steels.
3. Where a group of welding machines are connected to a distribution bus, the voltage variation of the bus expressed in per cent ± from the average value should be less than the voltage tolerance of the weld for successful welding.
4. The actual voltage tolerance permissible in any given case depends upon the weld quality requirements, material and material control, and control of welding conditions. These quantities must be established by the user. Suggested procedure is given in the body of the article for cases where conditions are unknown.
5. The total voltage drop to the welding machine does not influence weld quality since the machine can usually be adjusted to compensate for any fixed drop of voltage. Variation in voltage is the important factor from a welding standpoint. Voltage drop may influence control operation if drop becomes excessive.
6. Welding control circuits have certain voltage tolerance limitations. The control voltage must be maintained within these limits if they are to operate correctly.

Most electronic controls require their control voltage supply maintained within ±5% although they can stand 10% dip in voltage for short intervals of time.

7. Successful welding can be accomplished with voltage variation in excess of recommended values, but such practice does not give consistent and reliable welds and is not desirable for modern high-speed production requirements.

8. Where a group of machines are operating from a single bus, minimizing the voltage regulation to this point will minimize the voltage variation on the individual machines served from this bus.

9. Welding engineers are always in favor of minimizing voltage variation even beyond the weld tolerance limits in order to provide wider latitude in range of material and other conditions affecting the weld.

10. In general it does not pay to attempt to design the system regulation near the ragged edge of voltage tolerance. Any improvement will be most welcome in increased latitude and improved quality of welds. It also permits future growth possibilities.

11. The voltage variation requirements for gas-tight seam welding are usually more severe than for the spot welding of the same material.

12. The voltage variation requirements for projection, butt and flash welding are usually slightly less severe than for the spot welding of the same material.

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Arc-Welding Sewage Treatment Plant at Gary, Ind.

By A. F. Davis*

THE electric-arc process of joining metals has been employed to advantage in constructing the new sewage treatment plant at Gary, Indiana.

The large amount of piping, the many tanks and miscellaneous structural work have been welded with substantial savings in time and materials because of the electric arc's simplicity. This method joins pipe or structural members directly together without need of auxiliary connecting devices, thus eliminating extra operations and avoiding material wastes.

Providing joint metal which excels the metal welded in tensile strength, ductility, density and corrosion resistance, arc welding assures permanetly tight and leak-proof connections without surface projections to interfere with painting, insulating, etc.

Accompanying illustrations show typical examples of the many arc-welding applications in the new Gary plant.

An arc welder completing a circumferential butt weld in a 30-in. suction line in the pumping station can be seen in Fig. 1.

Figure 2 shows overhead welding on a 6-in. exhaust line from one of three gas engines which operate the sewage pumps.

A 6-in. arc. welded exhaust line for one of the gas engines which operate the sewage pumps is shown in Fig. 3. A complete line is shown in the foreground with a heat exchanger and muffler. The welder is working on a line in the background.

Figures 4 and 5 show a 36-in. discharge header in the pipe trench of the pumping station. Figure 4 shows a right-angle bend. Figure 5 shows a 24-in. discharge connection from one of the sewage pumps to the header.

Figure 6 is a view of the 36-in. air line showing the arc-welded longitudinal and circumferential joints. The pipe is shop fabricated and circumferential joints are arc welded in the field.

A view in the pipe gallery of the aeration control house where the incoming pipe lines are connected to the aeration basins is provided in Fig. 7. This piping is practically all of arc-welded construction. This work was done by L. H. Prentice Co., Chicago, Ill.

Figure 8 is a general view of the secondary clarifiers and aeration basins in the new sewage treatment plant. All of the railings and pipe leading to these basins are of arc-welded construction.

In Fig. 9 is a general view of the digestion tanks with one of three gas holders in the foreground of arc-welded construction. These holders were erected by United Boiler, Heating and Foundry Co., Hammond, Ind. The digester system is by The Dorr Co., Inc. The engineers on the project were Alvord, Burdick & Howson, Chicago, Ill.

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Fig. 1—Arc-Welding Butt Joint on 30-In. Suction Line

Fig. 2—Overhead Welding of 6-In. Exhaust Line

Fig. 3—A 6-Inch Arc-Welded Exhaust Line

Fig. 4—Right Angle Bend on 36-In. Discharge Header

Fig. 5—A 24-In. Discharge Connection

Fig. 6—Arc-Welded Joints on 36-In. Air Line

Fig. 7—Arc-Welded Pipe Gallery of the Aeration Control House

Fig. 8—General View of Secondary Clarifiers and Aeration Basins

Fig. 9—Digestion Tanks of Arc-Welded Construction

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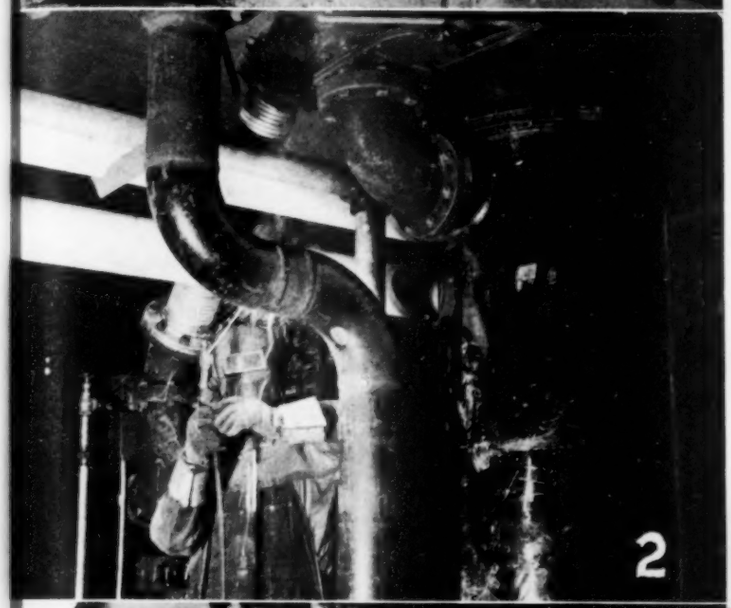
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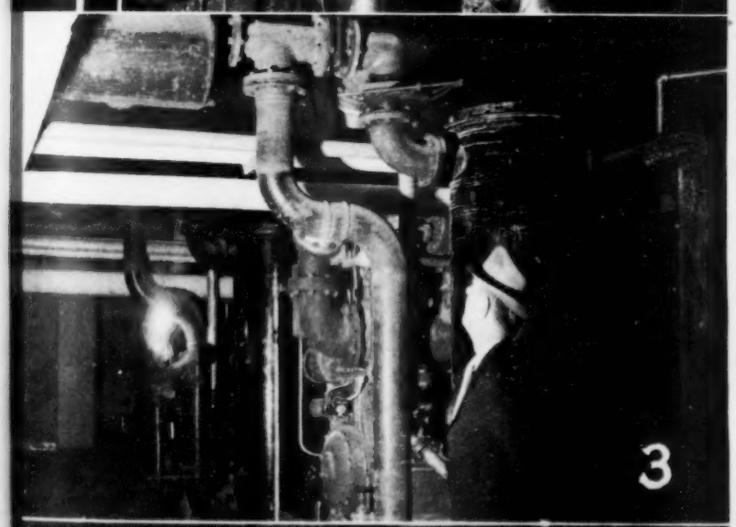
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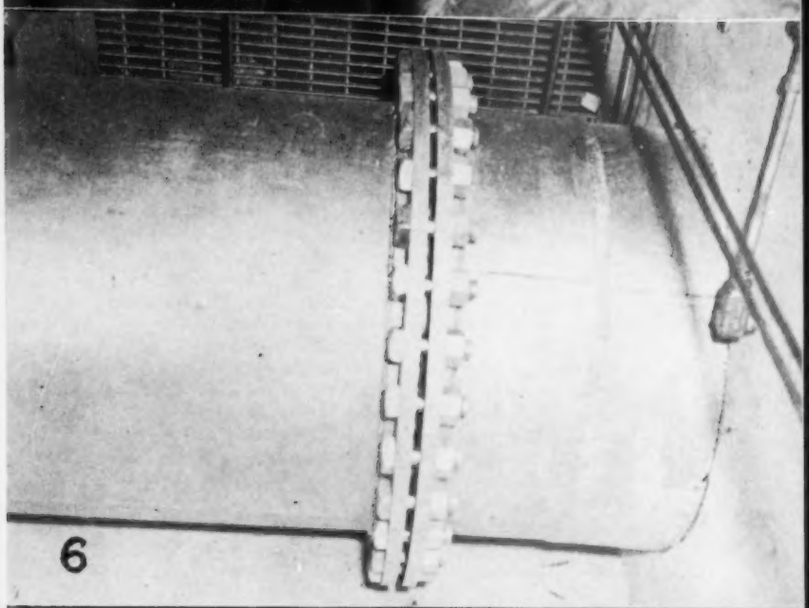
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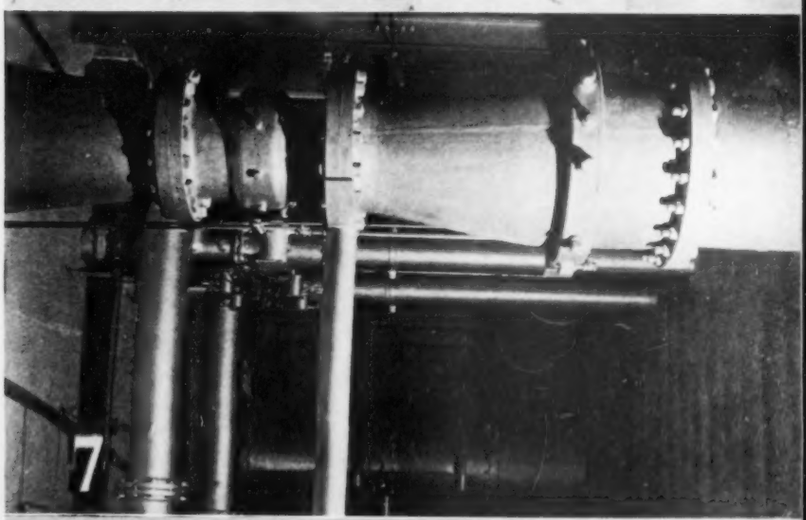
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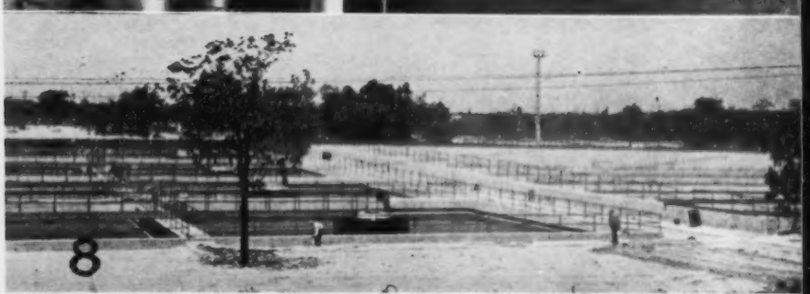
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THE AMERICAN WELDING SOCIETY

ACTIVITIES — RELATED EVENTS

PRESIDENT'S MESSAGE

In war production, standardization and simplification are important. Through them large economies are possible in the production of raw material, semi-finished parts and fabricated structures.

Welding is a comparatively new industry and its raw materials and methods may be less completely standardized than in the case of other processes. It seems highly desirable that every effort be made to simplify the raw materials of welding and standardize the procedures and methods of inspection. Any standardization program, however, must consider the complexities of the process and must meet the final requirements of the welded structure.

The two principal raw materials for arc welding are the electrode and the plate metal.

The plate metal must meet requirements as to physical and other properties, weldability and the properties of the welded joint. These characteristics are not dependent upon any single factor but upon several factors such as thickness, composition, methods of processing and heat treatment. All three requirements of the fabricator are affected by thickness as well as by composition. Likewise, the processing method and heat treatment of the plate influences both weldability and properties of the plate and of the joint.

There is no single composition of metal which will meet a given requirement of physical properties in different types of structures. In light sections such as used in aircraft, the plate metal is designed for service under high repeated stress loading. For some types of Ordnance specifying similar physical properties, a different composition may be permitted or required because of the difference in service conditions. Heavier sections require a higher carbon or alloy content for given strength than light sections.

In the present war program there is a greatly increased use of low-alloy steels for welded structures. For other products than welded structures and castings there has been a standardization of steel compositions. The S.A.E. low-alloy steels are predominant in rolled bars, forgings, etc. For low-alloy steel plates there has been no similar pressure from the fabricators and consumers to force standardization of composition. Steel producers have taken advantage of this condition in developing a large number of compositions which have been advertised for special qualities and marketed under brand names. This condition of multiplicity of compositions of low-alloy plates still exists as the recently developed N.E. standard compositions do not apply to plates. There will be changes in composition of plates in the direction of use of a minimum quantity of any one alloy but there is no evidence as yet of any attempt at standardization.

It would be highly advantageous to the fabricator if the composition of low-alloy plates could be simplified and standardized. There must be some variation in carbon and alloy content for variations in thickness but the welding fabricator's problem would be simplified if he had fewer compositions to deal with. In the future, this may not be so important as the present trend is to classify plates by hardenability characteristics rather than by compositions. If the welding engineer specifies hardenability and physical properties the steel mill has a wide latitude in the choice of alloys. Work in this direction is proceeding rapidly although the results are not yet available. In the meantime, simplification and standardization of compositions are in order.

Electrodes are classified by the fabricators on the basis of welding characteristics and joint properties. These classifications pertain to a given thickness of material and narrow ranges of composition. Standards for electrodes have been developed on the basis of types, diameters and lengths. The dimensional standardization appears rational. The types vary with position of welding, current characteristics and physical properties of the all-weld-metal. Seemingly, standardization has proceeded rather far. Actually, there is no real standardization of electrodes as each manufacturer has introduced special brands to meet specification requirements. These brands differ as to composition and nature of the coating. Because of variation in coatings, electrodes of a standard type but of different manufacture are not interchangeable. Generally, each brand has a special use and has found acceptance by fabricators for given products. It must be emphasized that the thickness of material welded is a primary factor in the selection of electrodes.

One difficulty in the present setup is the effort devoted to the qualification of electrodes for a fabricated product. Normally, this selection of electrodes devolves upon each fabricator although in the case of some war products the fabricator may be required to use electrodes qualified by Government agencies for special purposes. The mechanism of qualification and selection of electrodes is worthy of careful study.

It is highly desirable that the electrode producer be given rather great initiative in the improvement of electrodes. It seems probable, however, that technical developments could proceed just as rapidly and probably more rapidly if simplification in the variety of electrodes is effected. More fundamental research in weld slags and in the mechanism of the arc undoubtedly will yield far-reaching results. The development of electrodes would be accelerated by open discussion and publication of results of research and investigation.

There has been a tradition in American industry that standardization and simplification to be effective must be accomplished through producer-consumer cooperation. Neither element by itself has the knowledge and experience to prepare standards acceptable to industry. The AMERICAN WELDING SOCIETY, a strong fabricator organization, is in an excellent position to do constructive work along these lines. Possibly some further research results must be known before these problems can be settled. The Welding Research Committee is available and qualified for such work. Its present program will give information to help solve the problem. The whole question of standardization and simplification is rather complex and it must be handled by competent personnel if any real accomplishments are to be made. How much is accomplished will depend largely upon the fabricator.

WAR PRODUCTION BOARD

Division of Industry Operations

Distribution of welding rods and electrodes has been placed under strict control by an order announced by the Director of Industry Operations.

Welding rods and electrodes, under the terms of Limitation Order L-146, may be delivered without restrictions only to the Army and Navy, specified Government agencies, governments of the United Nations, for operations under the Lend-Lease program, and to accredited schools which are training welding operators under a course conforming to the AMERICAN WELDING SOCIETY'S code for minimum instruction requirements, or schools established within industrial plants which meet certain instruction qualifications.

Other deliveries of ordinary rods and electrodes are confined to orders bearing a preference rating of A-9 or higher. In the case of alloy electrodes or rods, which mean ferrous-base electrodes or rods whose core wire contains more than 2% by weight of materials other than iron or carbon, deliveries may not be made except on orders of A-1-J or higher.

Accredited schools are prohibited from using alloy rods or electrodes except in qualifying tests. They are also prohibited from furnishing to any apprentice more than one pound of rods or electrodes

per hour of instruction. They must certify to the person making delivery of this equipment that they are accredited schools, or that they are organized within an industrial plant and furnish a course intended to qualify an apprentice as an industrial welder in 200 hours or less of instruction.

The order also provides for the setting aside each month, for repair and maintenance purposes only, 6% of each type of rod or electrode delivered by a manufacturer during that month. Persons ordering rods and electrodes for repair and maintenance must so specify on their orders and must not use the equipment for any other purpose.

No one is permitted to acquire rods or electrodes if the result will be to increase his inventory beyond a 60-day supply. Manufacturers must file a record of all shipments with W.P.B. on Form PD-528 on or before the 18th day of each month. The order becomes effective June 13th.

MEMBERS IN ARMED SERVICE

At the May 7th meeting of the Board of Directors and Executive Committee of the AMERICAN WELDING SOCIETY, the remittance of dues of members in the armed forces was considered and the following actions taken:

In the case of members who had joined or been inducted into the armed forces and who because of this are unable to meet dues payment, upon request to the SOCIETY, the name of such member shall be continued on an "inactive" membership list for the duration of the war.

In the case of members who have joined or been inducted into the armed forces and who because of this are unable to meet dues payment, upon application to the SOCIETY, such member can obtain THE WELDING JOURNAL during this period at a nominal annual fee of $2.00.

The first action is intended to permit a member to retain membership without interruption, but does not provide for furnishing him with THE WELDING JOURNAL or other publications of the SOCIETY during this period. The second action makes it possible for the member to continue to receive THE WELDING JOURNAL at nominal cost. These rulings do not apply to commissioned officers.

MEETING BOARD OF DIRECTORS AND EXECUTIVE COMMITTEE

A meeting of the Board of Directors and Executive Committee of the SOCIETY was held in the Engineering Societies Building, on May 7, 1942.

Present were G. F. Jenks, *President*, presiding; (members) David Arnott, A. B. Bagsar, H. C. Boardman, E. V. David, J. H. Deppeler, R. W. Clark, O. B. J. Fraser, E. R. Fish, D. S. Jacobus, H. O. Hill, L. S. Moisseiff, F. L. Plummer; (non-members) E. E. Isgren, representing R. G. Le Tourneau, W. Spraragen, *Technical Secretary;* M. M. Kelly, *Secretary.*

Educational Committee

Mr. E. J. Del Vecchio was added as a member of the Educational Committee representing the Resistance Welding interests.

Douglass Memorial Resolution

A memorial resolution prepared by a special committee as a tribute to Colonel Douglass was approved and it was voted to transmit copy of the resolution to Colonel Douglass' family and to his associates in the Detroit Edison Company.

By-Law Amendments

A number of changes in By-Laws were acted upon. These relate to Committee on Awards, addition of Treasurer to the Permanent Funds Committee and clarification of the duties of District Vice-Presidents. Text of the revised By-Laws as approved were published in the June issue of THE WELDING JOURNAL.

Section By-Laws

A new revised suggested Standard Draft of By-Laws for local Sections was presented and it was agreed that these should be submitted with modifications to the Section Advisory Committee for their consideration before distribution to the Sections.

Finances

These were briefly reviewed by the Treasurer and found to be in excellent shape. Because of this fact it was felt possible to increase the total budget for

(*Continued on p. 468*)

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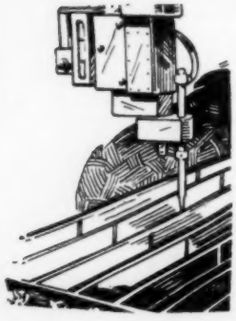

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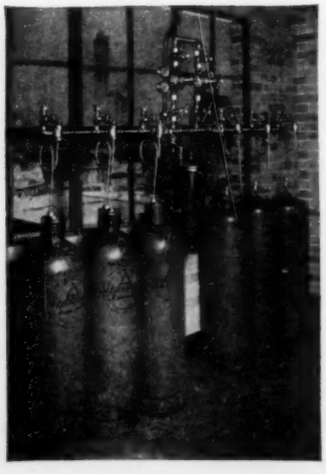

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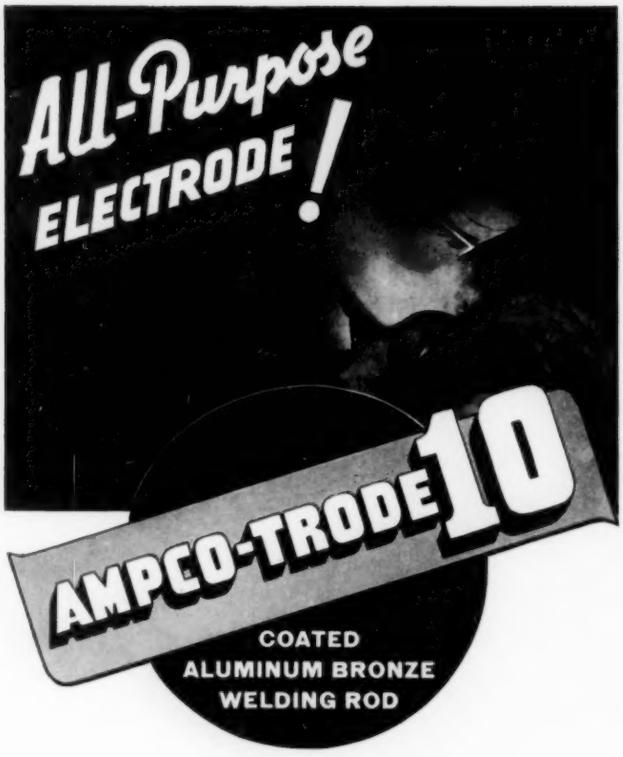

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Ampco-Trode 10 also welds or "brazes" dissimilar metals:—steel to cast iron; steel or cast iron to bronze, brass, or copper; or any of these metals to nickel alloys.

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You may be sure, however, that PAGE *was ready when the tremendous advantages—the greater speed—of welded construction were appreciated.*

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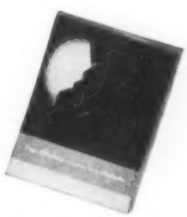

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the Annual Meeting from twenty-five hundred to three thousand dollars. At the request of the Finance Committee, this action was approved.

Remittance of Dues of Members in Armed Forces

After consideration of practices of some of the other technical Societies and recommendation of the Finance Committee, it was voted that in the case of members who have joined or been inducted into the armed forces and who, because of this are unable to meet dues payment, upon request to the SOCIETY, the name of such member shall be continued on an "inactive" membership list for the duration of the war.

This action is intended to permit a member to retain membership without interruption, but does not provide for furnishing him with THE WELDING JOURNAL or other publications of the SOCIETY during this period.

It was further voted that in the case of members who have joined or been inducted into the enlisted grades of the armed forces and who because of this are unable to meet dues payment, upon application to the SOCIETY, such member can obtain THE WELDING JOURNAL during this period at a nominal annual fee of $2.00.

It was agreed that this information should be transmitted to the Sections and suitable notice published in THE WELDING JOURNAL, and perhaps repeated for two additional times, every other month.

Rules to Govern Organization, Functions and Operations of Technical Committees as revised by a special committee and approved by the Committee on Outline of Work were approved. Any member may obtain a copy of these rules by writing to the Secretary. It was agreed that all technical committees should provide for an election of officers this year, the new term of offices to be effective with the new fiscal year.

Recommended Practices for Inspection of Fusion Welding

A report on this subject was approved for publication in the *Handbook* and as a separate bulletin. As soon as the *Handbook* is available, the editor expects to reproduce this bulletin in THE WELDING JOURNAL. Copies of the bulletin are available at 40¢ per copy.

Field Welding of Storage Tanks

It was agreed to approve changes in the present edition of the Rules for the Field Welding of Storage Tanks.

Definitions and Chart

New definitions and chart were approved for publication as the standards of the SOCIETY. These are now available in bulletin form at 40¢ per copy.

Filler Metal Specifications

Plans are now under way for the organization of a joint committee of the A.S.T.M. and A.W.S. to expedite revision of Filler Metal Specifications in the future. Revised specifications for Arc Welding Electrodes and Gas Welding Rods were approved. Electrodes for the Welding of Aluminum and Aluminum Alloys were approved for publication in the *Handbook* and will be issued as a separate bulletin as soon as formal approval of the A.S.T.M. is secured.

Procedure for Preparing War Emergency Standards

A procedure for eliminating of red tape in expediting the issuance of emergency war standards was approved. Copy of these rules is available upon request of the SOCIETY.

War Production Advisory Committees on Welding

Activities of the local Sections in the formation of War Production Advisory Committees were reviewed. It is expected to publish a résumé of these activities in an early issue of THE WELDING JOURNAL.

Welding Handbook

The Chairman of the Committee reported that it was his fond hope that the *Handbook* would be available for distribution on or about July 15th.

Membership

Present membership of the SOCIETY is about 5200.

1942 Annual Meeting

The location of the Annual Meeting in Cleveland during the week of October 12th was approved. A tentative program of this meeting is published elsewhere in this JOURNAL.

War Production Board Cooperation

The A.W.S. is cooperating with the War Production Board in providing for priorities of material to schools which meet the minimum requirements of the A.W.S. Actual certification of these schools will probably take place by the individual states.

SUMMARY OF REPORTS FROM SECTIONS, AMERICAN WELDING SOCIETY, IN REGARD TO RENDERING A WELDING ADVISORY SERVICE TO WAR INDUSTRIES

In response to a letter sent out from Headquarters to the Chairmen of the Sections of the A.W.S., a number of the Sections have reported on their activities in organizing War Production Advisory Committees on Welding.

CHATTANOOGA

The *Chattanooga* Section of the SOCIETY is sponsoring a class in Metallurgy and Welding, held once a week, conducted through the courtesy of the Combustion Engineering Company under the auspices of the University of Tennessee.

CHICAGO

Through a defense committee the *Chicago* Section is taking an active part and is a member of the Associated Defense Committees of the Chicago Technical Societies. As a member of this committee the Section cooperates very closely with the W.P.B. on welding problems. These activities involve the making of recommendations as to welding procedures on through the gamut of welding problems to the finding of suitable contractors or subcontractors to handle welding work.

CLEVELAND

The Secretary of the *Cleveland* Section writes:

1. For the last two years we have had a group of advisory committees generally classed as consultants, fabricators, manufacturing plants, a gas weld committee, an arc weld committee, a resistance weld committee, a metallurgical committee, to whom all may go for answers to their problems.

2. The Cleveland Technical Societies Council—who publishes the *Cleveland Engineering News* in which we participate—has recently announced a War Production Advisory Technical Service on all

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National Electric Welding Machines Co., Bay City, Mich.
Progressive Welder Company, Detroit, Mich.
Swift Electric Welder Company, Detroit, Mich.
Taylor-Hall Welding Corporation, Worcester, Mass.
Taylor-Winfield Corporation, Warren, Ohio
Thomson-Gibb Electric Welding Co., Lynn, Mass
Welding Machines Mfg. Company, Detroit, Mich.

ASSOCIATE MEMBER COMPANIES

S-M-S Corporation, Detroit, Mich.
Electroloy, Inc., New York, N. Y.
Welding Sales and Engineering Co., Detroit, Mich.
P. R. Mallory and Co., Indianapolis, Ind.

engineering matters, and we have agreed to lend our regular advisory committees to answer the welding questions. The procedure is that the problem must be in writing and through the General Council organization or direct to us and we pass it to the committee who meet, answer the question in writing, and send it back through the same channel by which it came, advising the services of a consultant if that seems indicated.

MILWAUKEE

The Executive Committee of the *Milwaukee* Section favors the establishment of advisory committees on welding and recommends (1) that the SOCIETY contact and inform the Governmental agencies such as Army, Ordnance, Navy, Air Corps and Maritime Commission that information and advice on welding is obtainable through the local Sections of the A.W.S. by having the inspectors of their local branches contact the Chairmen of the local Sections of the A.W.S. when information is needed.

Secondly, that the local Sections of the A.W.S., when contacted by the Governmental Department inspectors, appoint through their Chairmen advisory committees to act on the proposals brought to their attention.

[NOTE: In regard to plan proposed by the *Milwaukee* Section, it should be stated that the A.W.S. is not in a position to offer services of all Sections without a knowledge of the available talent in each of its Sections.]

NEW YORK

The Executive Committee of the *New York* Section believes that inasmuch as it is located in the same city as the National Headquarters of the AMERICAN WELDING SOCIETY, there would be little to be gained in the establishment of a local Advisory Committee on Welding, since such problems as might arise can be handled quite adequately by National Headquarters just as they have been in the past. However, the New York Section will be glad to cooperate with National Headquarters in any way which may seem desirable.

NORTHERN NEW JERSEY

Plans have been made for the establishment of an Industrial Advisory Service for the industries of the *Northern New Jersey Area*. The purpose of this service is to put as much welding knowledge and experience as possible at the disposal of industrial plants which are engaged in war work. A survey is being made of the membership of the section to determine what members are able and willing to contribute to this activity by furnishing information on problems relating to all forms of welding. The widest possible publicity has been given to this service with an invitation to send inquiries to the Section Secretary who will contact the members who are able to help with each inquiry and relay the suggestions received to the plant from which the inquiry originated. Section is also cooperating with the American Society of Metals on this work.

Action was taken also to develop a better coordination between welding schools and local industries. It was decided to make a thorough survey of existing schools, both public and private, and offer them the services of the Section Educational Committee in keeping their instruction procedures as closely as possible in line with local employment requirements. It is felt that the Section Educational Committee can be of very great service by building a better acquaintance and understanding between the schools and the prospective employers. The Educational Committee is already working on a plan for a course of lectures on the fundamentals of welding theory and practice to be given during the coming year.

OKLAHOMA CITY

In February of this year, the Educational Committee of the *Oklahoma City* Section suggested that their Section sponsor a council or group to serve in an advisory capacity to those engaged in defense work in this locality. The idea met with favor of the Executive Committee and the Educational Committee was instructed to prepare the necessary publicity to determine the requirements of the defense industry in this locality.

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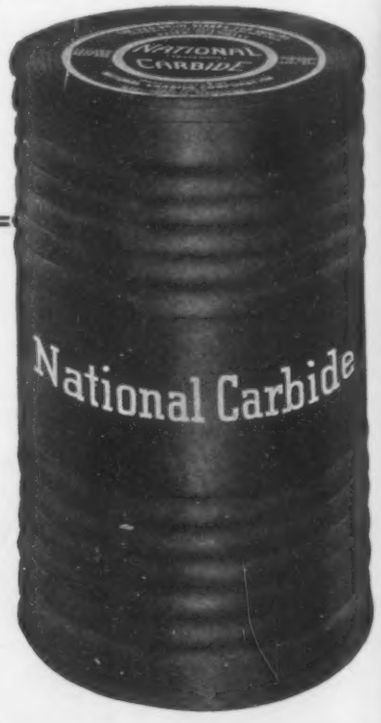

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Complete, detailed information on G-E cable for resistance welding is available in our new Bulletin GEA-3503. It contains useful data on how to select proper size of conductor, and a handy table of voltage drop for different ampere ratings. Useful to those who use resistance welding. Call your nearest G-E office or distributor. Or write to General Electric, Schenectady, N. Y.

GENERAL ELECTRIC

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Committee, composed of men specializing in the various fields of the welding art to render any aid, offer suggestions or outline procedures to individuals, large and small business firms and governmental or other organizations now engaged in Defense work.

The activity of this Committee is to augment the information which the local Section has already made available through the Carnegie Library in Oklahoma City. The various technical committees of the national organization will be consulted on problems beyond the scope of the local War Industries Advisory Committee.

This service is a part of the regular activities of the local Section and is to be made availabe through this Committee without charge.

Inquiries are directed to the "War Industries Advisory Committee" in care of the Secretary of the Oklahoma City Section of the AMERICAN WELDING SOCIETY.

PEORIA

After considerable study of the proposal, the Executive Committee of the *Peoria* Section unanimously felt that the formation of such an organization would be beneficial to this community. Too, they realized they were fortunate in having both capable men and a demand for their services in this particular field.

So the plan was adopted and the committee is to be known as the National Defense Advisory Committee on Welding.

Assistance will be solicited from the Peoria Manufacturers and Merchants Association who, we believe, can best conduct an investigation to ascertain where assistance is needed and who can successfully bring the matter before the proper authorities.

PHILADELPHIA

It is felt that there is but limited need for such a committee for the following reasons:

1. Practically all plants in this territory are staffed with personnel capable of handling all production and material problems.
2. Plants in this territory not having adequate engineering personnel are usually sub-contractors and such technical assistance as is required is furnished by the prime contractor.
3. The Philadelphia Engineers' Club now has such an advisory committee functioning, and the local A.W.S. Section has representation on this committee.

ROCHESTER

Careful investigation has been made of conditions in *Rochester* with reference to an advisory panel for the AMERICAN WELDING SOCIETY. Executive Committee feels that a special committee of this nature is unnecessary. Section has offered its services to anyone who might be interested through the War Production Board, Rochester Ordnance and Rochester Chamber of Commerce.

SOUTH TEXAS

The Executive Committee of the *South Texas* Section feels there is a need for an advisory service and is willing to cooperate. The members believe the Advisory Committee should be made up of A.W.S. and A.S.M. qualified members who are able to render impartial opinions; they further believe metallurgical members would be helpful in seeing that various materials to be welded are properly handled.

A Welding Committee cooperating with Lamar Junior College of Beaumont, Texas, on training of welding operators, has been in existence over a year. Several hundred welding operators turned out from this school are satisfactorily employed.

The Section Chairman believes a Committee will be helpful and is needed by Government schools in the preparation of courses for the training of welding operators for industries other than shipbuilding.

The Section officers state they will do everything in their power to see that our Government gets the benefit of the entire ability of its individual membership, all of whom are doing their utmost during this emergency.

YORK-CENTRAL PENNSYLVANIA

The officers and board of Directors of the *York-Central Pennsylvania* Section have decided that they are willing to form a "Local Advisory Board on Welding," provided conditions in the area warrant.

During the discussion, it developed that no one knew of any unanswered welding problems. The Chairman called the Local War Production Board and was informed that the Board also knew of no welding problems in this area.

The Section in November 1941 had appointed an Educational Committee to recommend instructors and instruction course for their local vocational training. At that same time, a Section representative was appointed on the "Local Advisory Committee for Defense Training," who should act as coordinator between the Section and the Local Advisory Board. Should there be a demand for a Local Advisory Committee on Welding, it is believed the Educational Committee may be a basis for its formation.

OBITUARY

J. S. Porter, Associate Member of the Oklahoma City Section, who was Sales Representative for the Westinghouse Company with offices in Oklahoma City, died on May 2, 1942, after several months' illness.

The movie colony has had an unusual opportunity to see and appreciate how fine a job the USO is doing for our men in the army and navy—through USO clubhouses, camp shows and many other services that make the life of service men easier and brighter.

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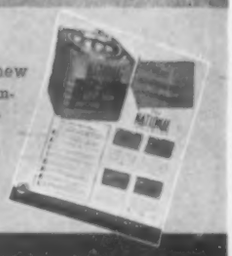
Try this modern welding method in your shop. The results will amaze you.

Welds: Cast Iron, Iron, Nickel, Steel, Aluminum, Bronze, Copper, Brass, Magnesium, etc.

EUTECTIC WELDING ALLOYS Inc. • 40 WORTH STREET NEW YORK, N. Y.

THREE NEW FLUX FORMULAS GIVE YOU CORRECT FLUXING ACTION THAT RESULTS IN SOUND WELDS...DENSE WELDS...and FAST WELDS EVERY TIME!

Write today for new bulletin giving complete details on these fluxes as well as National No. 22 aluminum flux.



NATIONAL CYLINDER GAS COMPANY

205 W. Wacker Drive — Chicago, Illinois

Offices in Principal Cities

Courtesy The Linde Air Products Company

FLAME HARDENING TURRET RINGS

Flame hardening finds an ideal application in the localized heat treatment of the bearing surfaces of tank-turret rings. The operation is entirely automatic. As shown in the illustration, the ring revolves past the stationary hardening unit in the foreground. The turntable is tilted so as to facilitate the disposal of the quenching water, which directly follows the oxy-acetylene heating flames. Only a fractional horsepower motor is required to drive the unit.

ARC WELDING MANUAL

Lessons in Practical Arc Welding, by Chaffee. 188 pages. 1942 copyright. Paper cover. Published by Hobart Trade School, Inc. 75¢ per copy. Special prices to schools.

This book contains the complete series of 41 arc-welding lessons offered at the Hobart Trade School. Chapter headings include: Preliminary Instructions; starting and Manipulating the Arc; Welding Common Joints with Bare Electrodes; Welding Light Gauge Sheets with Coated Electrodes; General Welding with Coated Electrodes in the Flat—Horizontal—Vertical—Overhead Position; Pipe Welding; Welding Cast Iron; Special Practice and Tests. Text also contains a suggested classroom procedure and ready reference index.

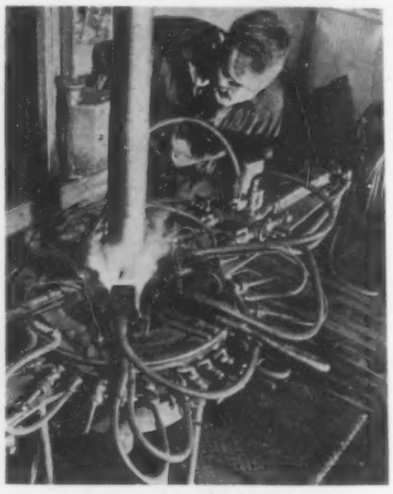
Lessons in Practical Arc Welding may be expected to become very popular in many trade schools throughout the United States since the author has explained the fundamentals of arc welding in a simple and easily comprehensible manner.

HANDY & HARMAN 75TH ANNIVERSARY

An attractive booklet was recently released to the 600 employees of Handy & Harman at the 75th Anniversary Banquets held in Bridgeport and New York May 14th and 15th. It tells in an unusual way some interesting facts about the company's history, facilities, products and the war work now in progress.

FLAME-HARDENING HELPS CONSERVE SCARCE ALLOY STEELS

The National Emergency steel specifications, recently announced by the War Production Board, cover a number of low alloy steels suggested as alternates for the standard alloy steels for the purpose of conserving critical materials. The Board also suggests that wherever possible carbon steel, intermediate manganese steel, carbon-molybdenum and manganese-molybdenum steel and silico-manganese steel be used. Use of steels containing strategic



Courtesy The Linde Air Products Company

This Shaft-Hardening Machine Was Made from an Up-Ended Lathe. During Hardening, the Shaft Is Rotated and the Flames Progress Upward, Followed by a Ring Quench

Buy "Proven Fluxes" with Years of Guaranteed Satisfaction behind them
The Trade-Name is "ANTI-BORAX"

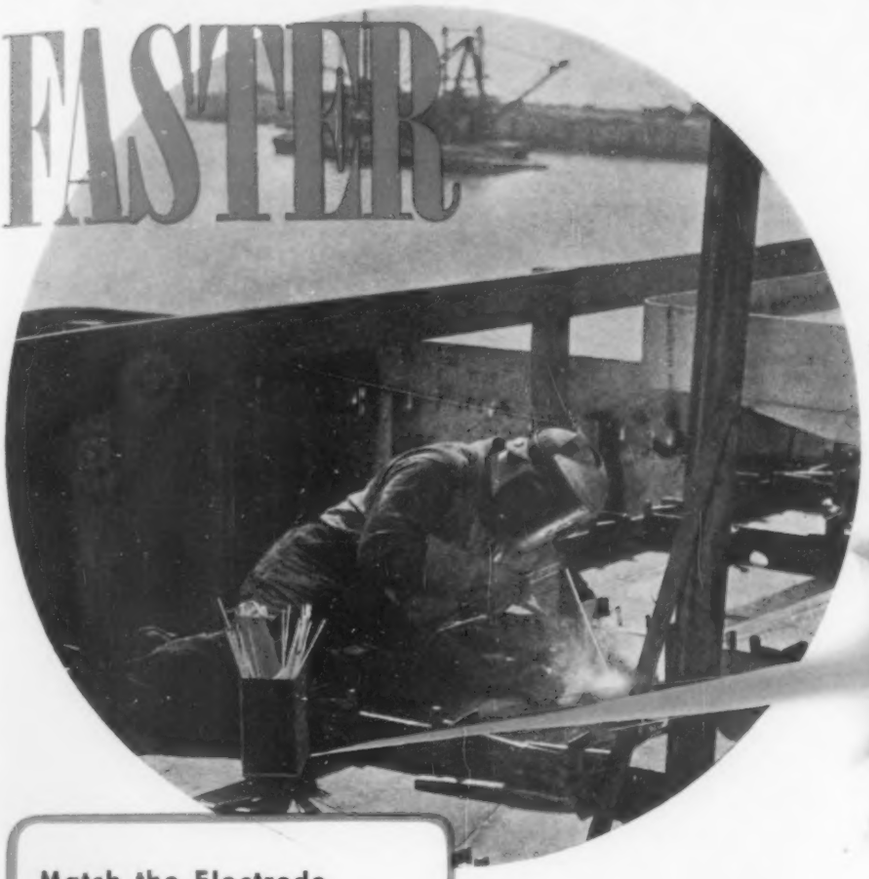
Ask for Them ***Unequalled for Quality***

A Flux for every metal: Cast Iron Welding Flux No. 1; Brazing Flux No. 2; Braz-Cast Flux No. 4, for bronze-welding cast iron; "ABC" Aluminum Flux No. 8 for sheet Aluminum and all alloys of Aluminum; Stainless Steel Flux No. 9; Silver Solder Brazing Flux No. 10; "Anti-Borax" Tinning Compound No. 11.

ANTI-BORAX COMPOUND COMPANY
Fort Wayne, Indiana

MAKE HEAVY FLAT WELDS LIKE THESE

FASTER



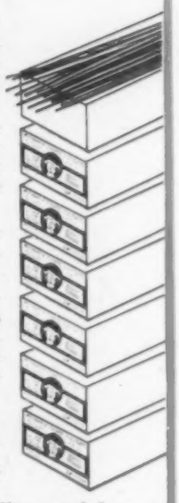
with Flexarc

DH

(DOWNHAND)

electrodes

Match the Electrode to the Job...!



FLEXARC FP—Use FP with a-c or d-c for fillet position and general-purpose, high-speed welding on low and medium carbon steels.

FLEXARC AP—For all position welding on low-to-medium carbon steels with minimum spatter. Reverse polarity d-c.

FLEXARC SW—Use SW for thin sheet metal welding. A general-purpose, all position electrode. A-c or d-c.

CASTINGWELD AND FREE-MACHINEWELD—For welding iron castings. Latter type made especially for work to be machined.

HARDENTOUGH—Four grades to meet all requirements of hard-surfacing machinery parts.

NICKELCHROM—For welding stainless steels.

NICKELMANG—For manganese steel welding.

THEY'RE MADE ESPECIALLY FOR HIGH CURRENT DOWNHAND WORK... BUTT AND FILLET WELDS

When you clamp DH in the jaws of the holder, you can really step up the speed of deep groove multiple pass welds on low and medium carbon steels without danger of undercut. Wherever large diameter electrodes and high currents are used for downhand work, DH "hot" rods will give uniform penetration, proper fusion and flat contours. The finished bead with DH is particularly smooth.

From the first pass to the finished bead, you'll have minimum spatter—even when currents are abnormally high. As a result, cleaning time and electrode loss are kept down. And welds which meet the most rigid code requirements are completed faster.

DH electrodes work equally well on both a-c and d-c. Available in diameters from $\frac{3}{32}$" to $\frac{3}{8}$". Try DH and be convinced. Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

J-21193

Westinghouse

FLEXARC ELECTRODES

elements such as nickel, chromium, tungsten, cobalt and vanadium is restricted.

By means of oxyacetylene flame hardening these suggested National Emergency steels can in many cases be used satisfactorily as alternates for the standard alloy steels for such parts as dies, shear blades, pump liners and piston rods. Flame hardening imparts a maximum hardness to the surface of quench-hardenable steels without changing their chemical composition or affecting the toughness and ductility of the core metal. Parts, therefore, can be furnace treated, if necessary, for special core properties and then flame hardened to produce the desired surface condition. Because of the flexibility of the process, the hardening effect can be restricted to only those surfaces where it is needed, and the degree and depth of hardness can be controlled accurately.

Flame-hardening equipment is light and easy to operate, consisting of one or more flame-hardening heads which furnish the oxyacetylene heating flames, an oil or water quench, and a means of propelling the head and quench at a set speed, or of turning the part being hardened.

CUTTING PAMPHLET

The Oxy-Acetylene Committee, International Acetylene Association, has just completed a second revision of the pamphlet entitled *Oxy-Acetylene Cutting* which pamphlet was originally prepared in 1934 and first revised in 1937.

The principal change in this latest revision is in connection with the table showing the cuttability of ferrous metals. The table and notes connected with same have been greatly clarified by better arrangement. Other changes have been included to bring it up to date.

ANALYSIS OF RIGID FRAMES

Analysis of Rigid Frames (An application of slope deflection), by A. Amirikian, C.E., Principal Engineer, Bureau of Yards and Docks, Navy Department. Book for sale by the Superintendent of Documents, Washington, D. C., price $1.00 (cloth).

This treatise on rigid-frame analysis is a compilation of a series of 44 articles by the author, previously having appeared as technical supplements to the Bureau News Memorandum.

These articles were written primarily for the benefit of the Bureau's technical personnel, as an aid in the design of continuous structures. However, the demand in excess of the limited supply of mimeograph reprints has made it necessary to republish the articles in book form.

In this national emergency, when conservation of all structural materials is a paramount necessity, the importance of modern methods of analysis, as a means of realizing appreciable savings in materials, cannot be overemphasized. To this end, this book is presented as a contribution to National Defense as well as to engineering literature.

CLEVELAND REPRESENTATIVE

Harold P. Blum has been appointed by the Metal & Thermit Corporation as its Cleveland territory representative to handle sales and service of the Murex line of arc-welding electrodes.

Mr. Blum, whose offices are located at 1615 Collamer Ave., will continue to represent Una Welding, Inc., with which he has been connected for several years, on automatic welding equipment.

POWER SHOW

The Advisory Committee for the 15th National Exposition of Power and Mechanical Engineering has recently been announced. Irving E. Moultrop is again chairman of the committee and John H. Lawrence is vice-chairman. Other members include Comfort A. Adams, E. G. Budd Mfg. Co.; Homer Addams, Past-President, American Society of Heating and Ventilating Engineers; J. T. Barron, Vice-President, Electric Operation, Public Service Electric & Gas Co.; R. E. Dillon, Vice-President, Production and Engineering, Boston Edison Co.; E. O. Eastwood, President, American Society of Heating and Ventilating Engineers; A. C. Fieldner, Chief Mechanical Engineer, U. S. Bureau of Mines; N. E. Funk, Vice-President, Engineering, Philadelphia Electric Co.; Wm. R. Hainsworth, President, American Society of Refrigerating Engineers; David Moffatt Myers, Consulting Engineer; Joseph Pope, Vice-President, Stone & Webster Engineering Corp.; Arthur L. Rice, Editorial Director, "Power Plant Engineering;" Charles F. Roth, Manager, Exposition; A. Bowman Snavely, Chief Engineer, Hershey Chocolate Corp.; E. K. Stevens, Associate Manager, Exposition; Philip W. Swain, Editor, "Power;" Alfred Vaksdal, Plant Engineer, Corning Glass Works; and Horace W. Wilds, Past National President, National Association of Power Engineers.

The Power Show management announces that 125 companies have engaged space to date, and exhibitors are planning displays that will help the war production program by showing how to get more out of existing equipment, ways and means of preventing shutdowns and insuring continuous operation. It is expected that the exposition will provide a valuable and timely service to industry by helping to solve production problems.

As in the case of previous Power Shows, the forthcoming event, scheduled for Grand Central Palace, New York, November 30 to December 5, is under the management of International Exposition Company. Permanent headquarters are at Grand Central Palace, New York.

ELECTRONIC WELDING TIMER

Sequence and automatic weld timers, which increase weld production and reduce outage time, are described in a new 6-page booklet announed by the Westinghouse Electric and Manufacturing Company.

The illustrated booklet gives application information and special design features; also diagrams showing complete sequence of operation in pulsation welding and how the electronic timer and other controls fit into the average resistance-welding circuit.

The electronic timer is designed for resistance welders using air or hydraulically operated electrodes, with solenoid-operated valves. Timing panels are available as either automatic weld timers or sequence timers.

These timers are adaptable for controlling spot, butt and projection welders.

A copy of booklet B-3079 may be secured from Department 7-N-20, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

ELECTROLOY ALLOYS for RESISTANCE WELDING ELECTRODES and DIES

Spot
Seam
Butt
Flash
Projection

ELECTROLOY ALLOYS were developed specifically for the resistance welding industry. ELECTROLOY ALLOYS cover the full range of physical properties necessary to the manufacturers and users of resistance welding equipment.

Our engineers will be glad to make recommendations for your special electrodes. Submit samples or specifications.

Catalog and prices available on request.

THE ELECTROLOY COMPANY, Inc. 1600 Seaview Avenue, BRIDGEPORT, Connecticut

"KNOW HOW" in welding shops will help to win this war!

U·S·S Special Rolled Steels for Welding Include:

U·S·S High Tensile Steels to resist corrosion and increase strength without adding weight.

U·S·S Copper Steels to give 2 to 3 times the corrosion resistance of plain steel at little additional cost.

U·S·S Abrasion-Resisting Steels to combat wear and friction.

U·S·S Heat-Resisting Steels for high-temperature service.

U·S·S Stainless Steel to reduce weight and assure high corrosion resistance.

U·S·S Carilloy Alloy Steels —Special Steels for the special jobs of industry.

Availability of these steels, of course, is dependent upon the nature of your use for them in relation to war production.

Use this U·S·S service to make your shop more productive

ON the production-for-victory line, no soldier is more important than the welder. This makes your job tougher, more pressing, more exacting than it has ever been before. You are being confronted with entirely new design problems, steels that are unfamiliar to you, radical changes in welding technique. And you are taking them in stride!

In this task we can often help to make your job easier and speedier. As the nation's largest producer of rolled steels, we are familiar with their characteristics and the welding techniques which permit their use to best advantage. Through years of application experience, our welding engineers have gained much practical knowledge which they will be glad to pass on to you.

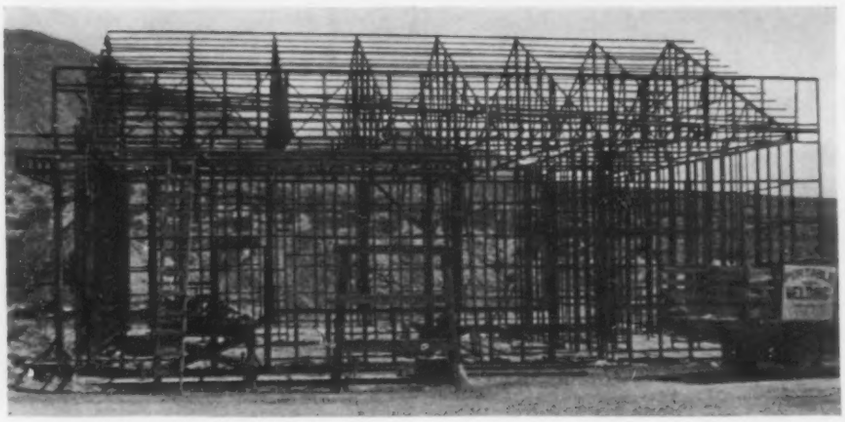
Bring your most perplexing problems to us. Your job is production. Why take time to experiment, when we may already have the answer? We have made it our responsibility to be able to keep you posted on the best ways to use U·S·S Rolled Steels in welding construction. Write for the information you need.

U·S·S ROLLED STEELS FOR WELDING

CARNEGIE-ILLINOIS STEEL CORPORATION, *Pittsburgh and Chicago*
COLUMBIA STEEL COMPANY, *San Francisco*
TENNESSEE COAL, IRON & RAILROAD COMPANY, *Birmingham*

United States Steel Export Company, New York

UNITED STATES STEEL



Courtesy Hobart Brothers Co.

WELDED GAS STATION

Five fires, with losses totaling over $68,000 have been the unlucky plight of C. H. Riffle, owner of a huge super service station and garage in the heart of the Mojava Desert in California. To quench his fire losses, Riffle built the 50 x 50 ft. all-welded gas station shown under construction.

Over a mile and a half of used pipe was used in the framework for this station. First, the entire side frame of $2^1/_2$-in. pipe was laid out and welded in sections on the ground. Bottom ends of the wall frame were fillet welded with $^3/_{16}$-in. mild steel rod and bolted to the concrete foundation. As each section was raised, it was butt welded to the previous one with $^5/_{32}$-in. rod. Cross braces, made from $1^1/_2$ in. pipe, were welded in a similar manner.

Roof trusses, made from $1^1/_2$-in. pipe also, were fabricated on the building site. Extreme care was taken to make tight and snug fittings throughout the framework. Framework was covered with sheet iron and painted. Total cost of previous wooden frame building was $7000. Cost of welded pipe building was $4500. Entire framework was constructed by Warren H. Martin, job welder, of Red Mountain, Calif.

BEHIND THE MEN BEHIND THE GUNS

Behind every machine gun, tank, airplane and ship are countless machine tools operated by thousands of skilled workmen. The picture shown below illustrates the battle of production in the plants of a typical American industrial firm—the Westinghouse Electric and Manufacturing Company.

"ELIMINATION OF OXYGEN WASTE" CAMPAIGN

As part of a campaign against waste of oxygen in welding and cutting operations, two posters for display in plants where oxyacetylene processes are used have been made available. Both posters dramatize oxygen's importance to war production and emphasize the need for its conserva-

Annual Meeting

American Welding Society

Oct. 12-16, 1942

Cleveland, Ohio

NET ADVERTISING RATES

Black and White *Effective May 1938*

Space	One Insertion	Three Insertions	Six Insertions	Twelve Insertions
*Full Page	$100	$90	$80	$70
Half Page	60	50	45	40
Quarter Page	35	30	27	25
Eighth Page	25	20	17	15
*Inside Preferred	115	105	95	85

*10% Extra for bleed full pages. Color $40 Extra per color added.

GET MORE UNIFORM WELDS ON ALUMINUM

Increase Volume, Too, By First Preparing Surfaces the Faster, Safer Oakite Way!

Successfully used by leading aircraft concerns, the Oakite process for surface preparation of aluminum effectively and safely removes oxide films and enables each machine operator to turn out MORE UNIFORM, stronger welds. Complete technical data free to production and engineering executives requesting it on their Company letterhead.

OAKITE PRODUCTS, INC., 18E Thames Street, NEW YORK, N. Y.

Representatives in All Principal Cities of the United States and Canada

OAKITE Specialized CLEANING

MATERIALS · METHODS · SERVICE FOR EVERY CLEANING REQUIREMENT

STARTLING NEW DEVELOPMENT FOR INDUSTRIAL X-RAY INSPECTION!

The standard assembly of this latest development in the use of X-ray for industry, showing the control, generator and tube carriage.

KELLEY-KOETT THREE PURPOSE UNIT OPENS BROADER FIELD FOR X-RAY USE . . . . .

MUCH interest has been aroused by a new X-ray inspection tool just announced for the industrial field. This efficient unit combines *conventional radiography* for the inspection of thin welded sheets; *microradiography* for investigating alloy compositions and other materials; X-ray *diffraction analysis* for the study of crystalline structures.

THIS all-around KELEKET unit is an important milestone in the development of broader industrial uses for the X-ray.

Creators of quality X-ray apparatus for the medical profession since 1900, KELEKET has pioneered the design and construction of equipment for X-ray inspection in industry.

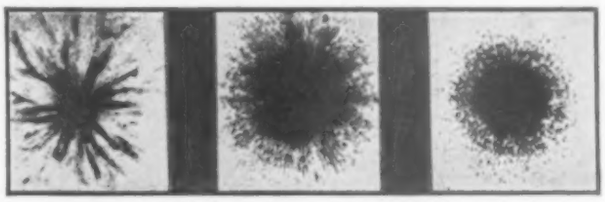
From the thinnest aluminum sheet to heavy armor plate, X-ray examination with KELEKET equipment is revealing hidden flaws, preventing unnecessary machining, disastrous failures, and pointing the way to the development of stronger, better substitutes for critical raw materials.

Industrial managers with an inspection problem and interested in X-ray examination are invited to consult with KELEKET industrial X-ray engineers.

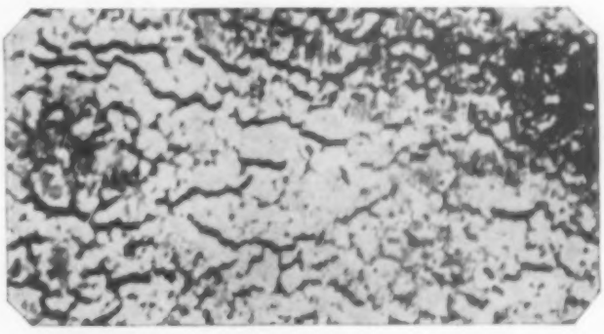
THE KELLEY-KOETT MFG. CO., *Industrial Division*
218-7 WEST 4th ST., COVINGTON, KY.
Representatives in 64 Cities

KELEKET X-RAY

INDUSTRIAL EQUIPMENT



The figure shown above was secured by means of this new multi-purpose X-ray unit. It shows three diffraction patterns of one sample of steel. On the left, the molecules are arranged haphazardly and under great strain. After partial annealing, the center pattern is obtained, the molecules having rearranged themselves in a more symmetrical fashion. After complete annealing, the pattern on the right indicates all strain has been relieved.



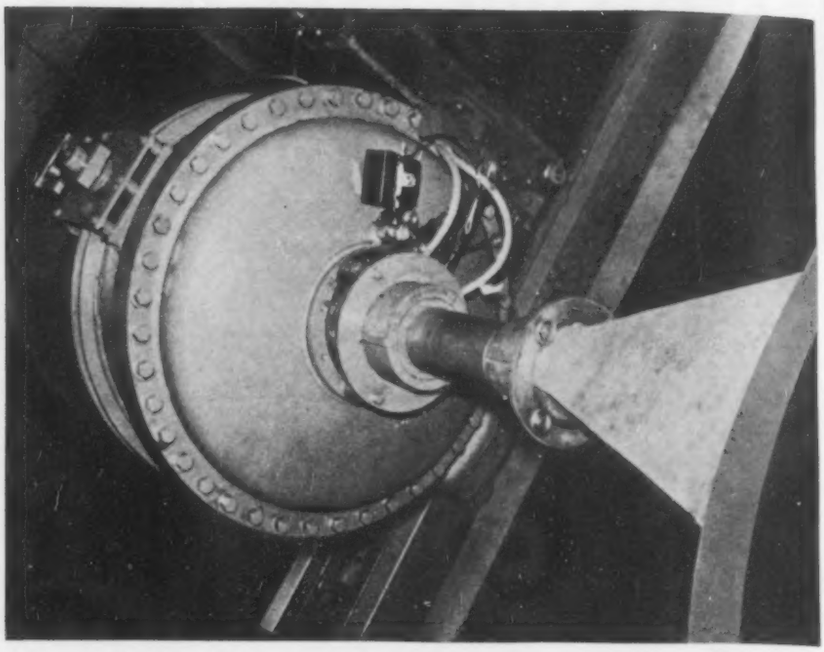
A microradiograph of cartridge brass taken with this new X-ray unit shows season cracks. The relative density of shadows indicates whether cracks extend partially or all the way through the specimen.

PIONEER CREATORS OF *QUALITY* X-RAY EQUIPMENT SINCE 1900

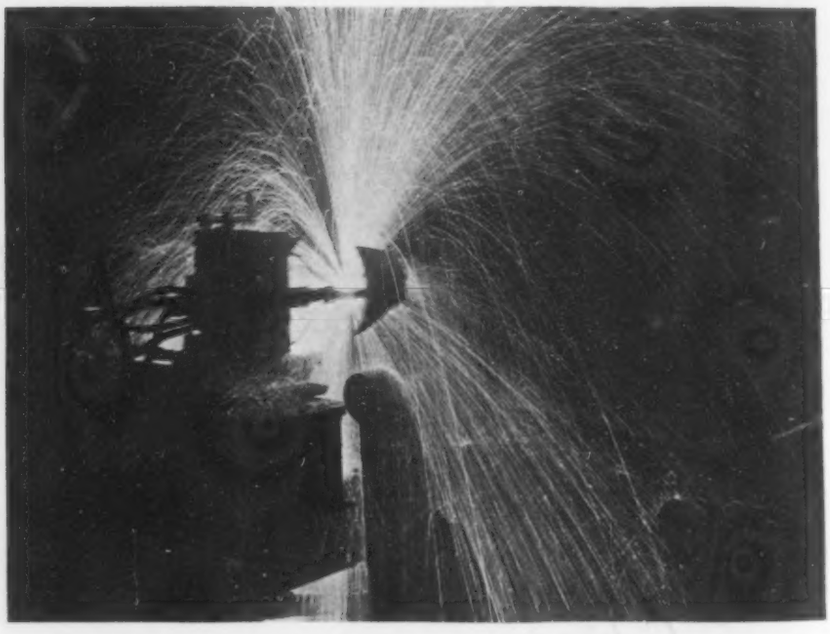
OXYGEN is vital · ·
DON'T WASTE IT
Turn off torches when laying out work.
Do not use wasteful pressures or oversize tips.
Check hose and connections regularly for leaks.
Use all the gas in each cylinder before connecting a new one.
Close cylinder valves when not in use.
Keep tips clean.
Be sure equipment is in good working order.
Help your pals in the Armed Services
FIGHT WASTE

tion. Eye-catching colors and illustrations give both pieces high attention value.

No advertising appears on either poster. Light weight paper stock permits easy mounting anywhere in the shop. Write for free copies which will be sent postpaid in any quantity desired. Address G. Van Alstyne, Air Reduction Sales Co., 60 E. 42nd St., New York, N. Y.



Million Volt X-Ray Machine in Position Over Boiler Drum at the Barberton Plant of the Babcock & Wilcox Co.



Centering Tube Rounds with Acetylene Torch—The Babcock & Wilcox Tube Co., Beaver Falls, Pa.

ROLLER

This huge three-drum SheepFoot Roller, built by the R. G. Le Tourneau Co., is a crushing steel giant for major grading and road building projects. The entire roller is built by arc welding—using spinner jigs, shown at the right, to facilitate fast production. The rollers weigh 7000 lb. empty, and may be filled with water for heavy-duty work.

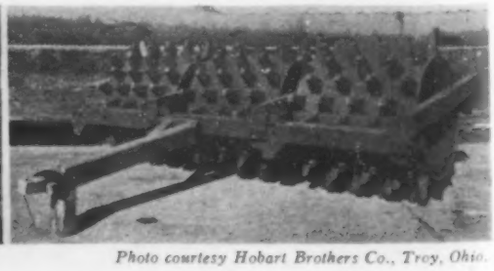
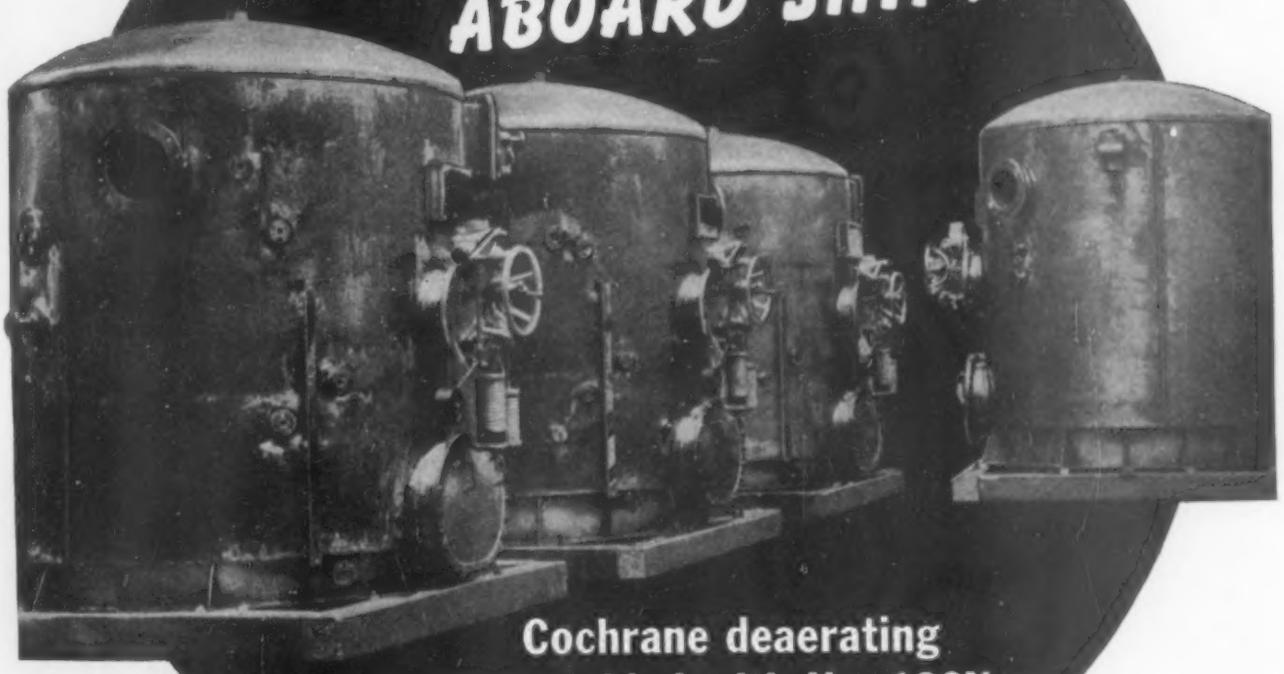


Photo courtesy Hobart Brothers Co., Troy, Ohio.

FOR MINIMUM WEIGHT ABOARD SHIP...



Cochrane deaerating heaters welded with No. 130X Monel arc welding rod

Deaerating feed water heaters made of Monel by Cochrane Corporation, Philadelphia, Pa., of welded construction, employing No. 130X Monel arc welding rod.

TYPICAL of welded Monel* construction, are these Cochrane deaerating feed water heaters. Used in ships of the navy and merchant marine, they protect feed piping, economizers, and steel boiler tubes against corrosion.

These units, made of Monel, are of welded construction, employing No. 130X Monel arc welding rod.

Monel, Nickel, Inconel* and Nickel-clad steel, widely used in equipment building for defense, are readily welded. Which rods and fluxes to use? Refer to the box at right. Write also for complete working instructions. Address:

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York, N. Y.

INCO WELDING RODS and FLUXES

MONEL

Oxy-Acetylene . . . No. 40 Monel Gas Welding Rod — Monel Gas Welding Flux.
Metal Arc . . . No. 130X Monel Metal Arc Welding Rod.

NICKEL

Oxy-Acetylene . . . No. 41 Nickel Gas Welding Rod — no flux is used.
Metal Arc . . . No. 131 Nickel Metal Arc Welding Rod.

INCONEL

Oxy-Acetylene . . . No. 42 Inconel Gas Welding Rod — Inconel Gas Welding Flux.
Metal Arc . . . No. 132 Inconel Metal Arc Welding Rod.

NICKEL-CLAD STEEL

Metal Arc . . . No. 131 Nickel Metal Arc Welding Rod.

INCO MONEL

*"Monel" and other trade-marks which have an asterisk associated with them are trade-marks of The International Nickel Company, Inc.

List of New Members

May 1 to May 31, 1942

BIRMINGHAM

Le Gore, James A., Jr. (D), 5007—16th Ave., N., Birmingham, Ala.

BOSTON

Cunniff, William H., Jr. (D), 49 Williams St., E. Braintree, Mass.
Doucette, John P. (D), 34 Pleasant View Ave., E. Braintree, Mass.
Heffernan, Paul (C), 314 Bartlett St., Portsmouth, N. H.
Horwitz, Sol (B), West End Iron Wks., 122 Hampshire St., Cambridge, Mass.
Masterson, James (D), 202 Highland St., Roxbury, Mass.
Ruel, Hubert N. (D), 119 Pond St., S. Weymouth, Mass.

CANADA

Barr, James W. (D), 271 Beechwood Ave., Victoria, B. C.

CANTON

Aman, Dexter S. (D), N. Main St., Navarre, Ohio.
Stewart, Charles F. (B), 848 Market Ave., N., Canton, Ohio.

CHICAGO

Jensen, Arnold C. (D), 8445 Luella Ave., Chicago, Ill.
Johnson, Roy F. (B), Pullman Standard Car Mfg. Co., 79 E. Adams St., RM. 703, Chicago, Ill.
Mansfield, Raymond B. (B), Zenith Radio Corp., 6001 Dickens Ave., Chicago, Ill.
Nauman, Leonard (D), 10948 Vernon Ave., Chicago, Ill.
Quigley, James B. (B), Graver Tank & Mfg. Co., 6818 Ontario St., Hammond, Ind.
Russell, Theodore W. (B), 5844 W. Barry Ave., Chicago, Ill.
Tonge, Maxwell (D), 2152 W. Division St., Chicago, Ill.

CINCINNATI

Martin, Raymond C. (C), Rt. 5, Box 127, Lockland, Ohio.
Rolfes, Frank H. (C), 5914 Woodmont Ave., Cincinnati, Ohio.

CLEVELAND

Barton, James R. (D), 9106 Marshall Ave., Cleveland, Ohio.
Deucher, Robert (B), 10225 Meech Ave., Cleveland, Ohio.
James, Alvah L. (C), 9403 Easton Ave., Cleveland, Ohio.
Schreeck, Carl W. (C), 1740 Page Ave., E. Cleveland, Ohio.

COLUMBUS

Harvey, William D. (F), 1978 Iuka Ave., Columbus, Ohio.
Simmons, C. B. (B), S. Zanesville, Ohio.

CONNECTICUT

Parks, Chas. (B), Bullard Co., Bridgeport, Conn.

DETROIT

Foss, Glendon E. (C), 6824 Calhoun Ave., Dearborn, Mich.
Jakomowicz, John (C), 2676 Eveline, Hamtramck, Mich.
Kurlinski, T. (C), National Elec. Welding Machs. Co., 1846-60 N. Trumbull St., Bay City, Mich.
Neitzel, Henry C. (A), Whitehead & Kales Co., 58 Haltiner, River Rouge, Mich.
Van Steenkist, Henry (C), 18046 Strasburg, Detroit, Mich.

GEORGIA

Fulton, John W. (C), % Southeastern Shipbldg. Corp., P. O. Box 1881, Savannah, Ga.

HAWAII

Veteto, Paul, Jr. (D), 700—17th St., Defense Housing, Honolulu, T. H.

LOS ANGELES

Coburn, William E. (D), Box 437, Lawndale, Calif.
Gregory, Harry G. (D), 8942 S. Cimarron St., Los Angeles, Calif.
Wilson, Clyde, Jr. (C), 1447 E. 71st St., Los Angeles, Calif.

LOUISIANA

Geffs, Frank A. (B), Equitable Equip. Co., 410 Camp St., New Orleans, La.

MARYLAND

Griffin, Thomas (C), Koppers Co., 200 Scott St., Baltimore, Md.
Middaugh, G. V. (C), Koppers Co., 200 Scott St., Baltimore, Md.
Peck, Sanford J. (D), 2535 McHenry St., Baltimore, Md.

NEW YORK

Beatty, Howard G. (D), 90-38—170th St., Jamaica, N. Y.
Brookshire, Joseph H. (D), 91—2nd St., Brooklyn, N. Y.
Davis, William C. (D), 1205 Ave. R, Brooklyn, N. Y.
Phipps, R. E. (D), 1300 York Ave., New York, N. Y.
Robinson, Thomas F. (C), New York Trade School, 324 E. 67th St., New York N. Y.
Schaub, Robert W. (D), 15 Brower Ave., Ocean Side, L. I., N. Y.
Shavelenko, Igor A. (D), 1997 Hughes Ave., Bronx, N. Y.
Winter, Edward L. (D), 832 Post Ave., W. Brighton, S. I., N. Y.
Zimmel, Frank J., Jr. (D), 49-04—67th St., Woodside, L. I., N. Y.

NORTHERN NEW JERSEY

Caroselli, Dominick (D), 345 Newark Ave., Jersey City, N. J.
Constantinople, Jack (D), 388—15th Ave., Newark, N. J.
Dumsian, Joseph (D), 84 Irving St., Jersey City, N. J.
Fleischman, Sam (D), 50 Storms Ave., Jersey City, N. J.
Kraft, Claude A. (D), 209 Lake Ave., Lyndhurst, N. J.
Langlitz, Albert (D), R. D. 2, Wallkill, N. Y.
Markman, Frederick P. (D), 329 Chestnut St., Audubon, N. J.
Mayer, Frank E. (D), 72 Magazine St., Newark, N. J.
Mitchell, Samuel M. (D), 614 Ridge Rd., Lyndhurst, N. J.
Ostermann, Henry (D), 2 Dela Anna Ave., Delawanna, N. J.
Singerle, Charles (D), 31 High St., Jersey City, N. J.
Sweigman, Seymour (D), 496 Hawthorne Ave., Newark, N. J.

NORTHERN NEW YORK

Daniels, Franklin W. (F), 267—8th St., Troy, N. Y.
Parks, John M. (C), Rensselaer Polytech. Inst., Ricketts Lab., Troy, N. Y.

PHILADELPHIA

Ashbrook, R. L. (D), 7322 Bryan St., Mt. Airy, Philadelphia, Pa.
Blanke, John A. (C), 209 Haakon Rd., Brooklawn, N. J.
Callender, Edwin M. (C), 16 W. Stewart Ave., Lansdowne, Pa.
Rice, William (B), Bok Vocational School, 8th & Mifflin Sts., Philadelphia, Pa.
Wayne, Lawrence J. (B), 5020 Holmecrest Rd., Fairway Terrace, Pensauken, N. J.

PITTSBURGH

Campbell, George C. (D), R. D. 3, Coraopolis, Pa.
Dailey, Donald L. (C), R. D. 1, Butler, Pa.

PUGET SOUND

Halladay, Glenn C. (D), 2643 Terrace Ave., Bremerton, Wash.

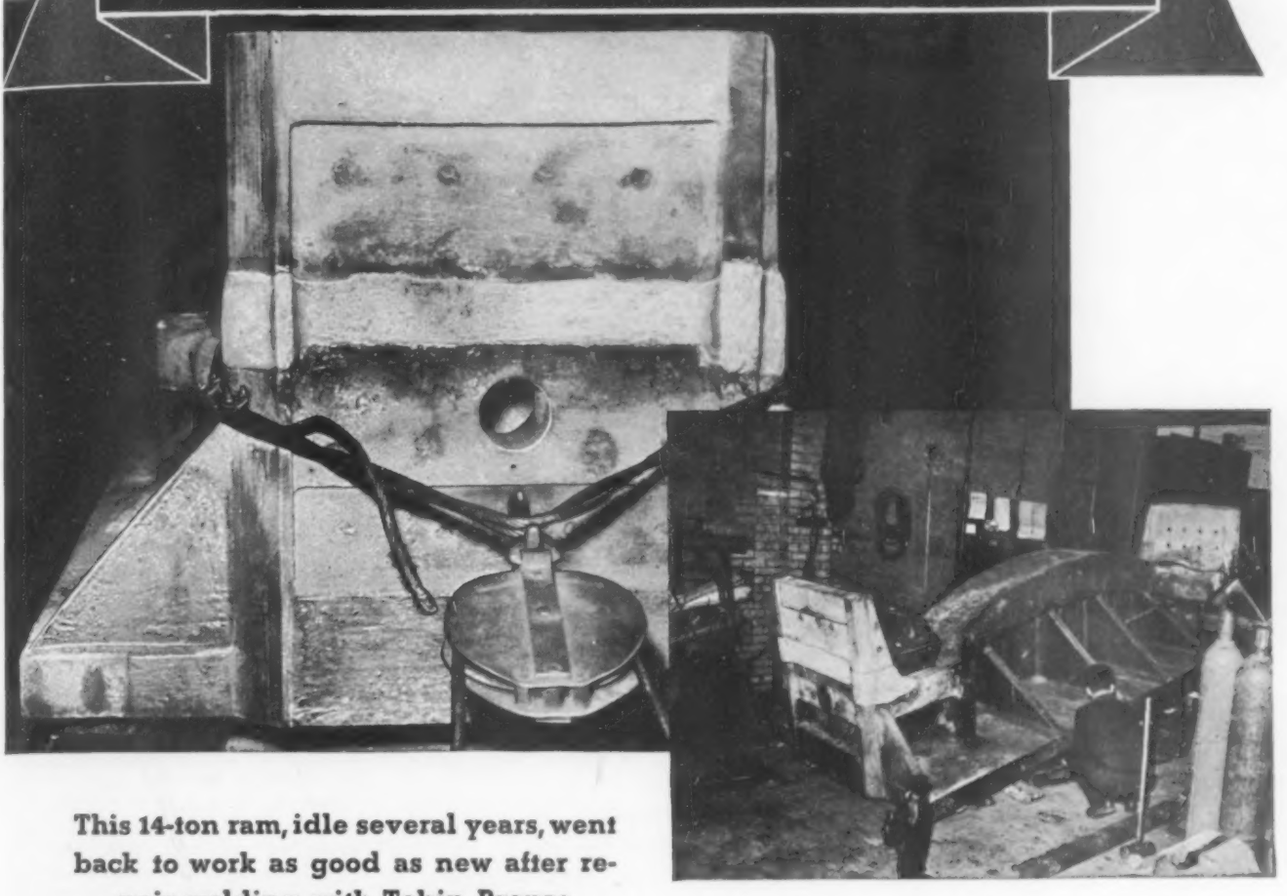
ROCHESTER

Hed, Andrew (C), % Flesch & Schmitt, Inc., 118 Brown St., Rochester, N. Y.

ST. LOUIS

Howery, James A. (C), 4316A Lexington Ave., St. Louis, Mo.

Speeding war work through Tobin Bronze Welding!



This 14-ton ram, idle several years, went back to work as good as new after repair welding with Tobin Bronze

Rams of this size take months to manufacture and deliver. So, when this one was found coincidentally with a call from a war job for such a piece of equipment, everyone felt quite happy . . . for awhile. Inspection revealed a badly patched fracture which probably occurred many years ago.

Undismayed when it examined the ram, the Super Arc Welding Company of Detroit set out to put the equipment into first-class operating condition . . . by Tobin Bronze Welding. After three days of adjusting the parts, they started preheating and welding. Three days later, with the help of 1750 pounds of Tobin Bronze, this ram went to work on war production.

• • •

Tobin Bronze and other Anaconda Copper-Alloy Welding Rods are always "on call" for war production work. 4297

ANACONDA from mine to consumer

Anaconda Welding Rods

THE AMERICAN BRASS COMPANY, General Offices: Waterbury, Connecticut

In Canada: Anaconda American Brass Ltd., New Toronto, Ont. • Subsidiary of Anaconda Copper Mining Company

SAN FRANCISCO

Alexander, George W. (D), 480 Springs Rd., Vallejo, Calif.
Axenty, Stuart E. (D), 200 Madison St., Vallejo, Calif.
Callahan, Hubert J., Jr. (D), 3759 Canon Ave., Oakland, Calif.
Cole, Everett H. (D), 1808 Octavia St., San Francisco, Calif.
Costerouse, Alphonse (D), 156 Maddux Ave., San Francisco, Calif.
Graham, Douglas E. (D), 3909 Shafter Ave., Oakland, Calif.
Oltman, Frederick (D), 2197 Divisadero St., San Francisco, Calif.
Sahlberg, Manley W. (C), 403 Latham Sq. Bldg., Oakland, Calif.

WESTERN NEW YORK

Kliemann, Otto (C), Farnham Mfg. Co., 1646 Seneca St., Buffalo, N. Y.
Sweitzer, Leroy E. (B), 205 Rodney Ave., Buffalo, N. Y.
Ulrich, Carl F. (B), 69 Thatcher Ave., Buffalo, N. Y.

WICHITA

Newkirk, R. M. (C), 1553 N. Poplar, Wichita, Kans.

NOT IN SECTIONS

Hudson, Sherman (D), Walker, Iowa.
James, E. T. (C), Rockford Lane, Shively, Ky.
McDonald, A. E. (B), 3704 Homewood Ave., Toledo, Ohio.
McIntosh, O. L. (D), Wayne Mach. Wks., Monticello, Ky.
Shaffner, George W. (C), Lake Mattoon, Mattoon, Ill.
Sweat, Charley M. (D), Rt. 2, Box 84, Port Arthur, Tex.

Employment Service Bulletin

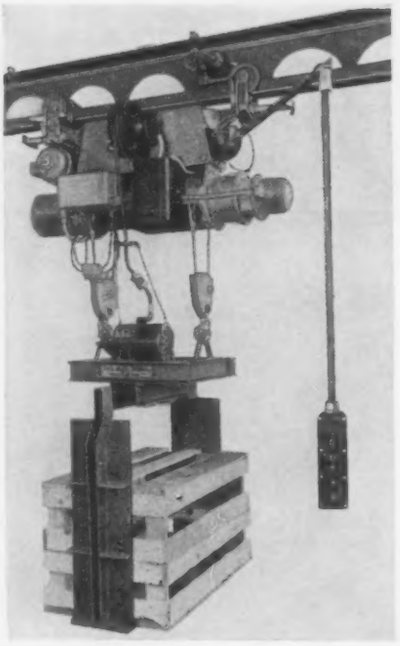
POSITION VACANT

V-119. Welder and hard facer. Experienced operator wishing to change from non-defense work to traveling demonstrator and sales engineer wanted by company manufacturing products used in defense plants. Machine shop experience desirable. Send in confidence full details of education and background, experience, salary expected and snapshot (not returnable) with first reply.

CRATE GRAB AND CARRIER

One of the newest developments of the Cleveland Tramrail Division of The Cleveland Crane & Engineering Co., Wickliffe, Ohio, is the motor-driven welded crate grab and carrier especially designed for handling crates and boxes in and out of storage, or from one elevation to another. The unit enables the quick stacking or removal of crates at a great height with safety. This makes possible faster handling, and also greater storage capacity of a given area.

The grab and carrier are completely motorized with all operations conveniently controlled by the six buttons of the push-button station. If desired this type unit can be provided with an operator's cab in which all controls may be located.



The unit illustrated will handle one or more boxes at a time. It will lift loads up to 1500 lb. a distance of 20 ft. The arms may be spread to a maximum of 36 in. and retracted to a minimum of 18 in. Similar units can be built for heavier loads and to suit other dimensions.

COMMUNICATION TO THE EDITOR

60 Allen Street
Groton, Conn.

Editor, Welding Journal,

Dear Sir:

I believe your readers would be interested in a new method of preventing weldments curling under the heat so as to require expensive straightening. It has been perfected within the past three or four months by workmen at the Electric Boat Company plant in Groton, Conn., where most of Uncle Sam's submarines are built.

In the past it was customary, if a stiffener was to be welded to a bulkhead or just at right angles to a small foundation piece, to dog the first piece down securely to the welding blocks then go to it.

Now it has been found that a strip of pine laid underneath the first piece along the line of the weld can be used to prevent the curling which would result under the old system.

The metal is dogged down over the pine so that it is under a certain amount of tension. As the metal is heated in the welding process its tendency to pull upward is offset by the downward tension and with a little practice the shipfitters and welders are able to judge the necessary thickness of wood and amount of tension so that almost perfect results are obtained with very little, if any, straightening required.

This system has been used with remarkable success on bulkheads and the flat sides of battery tanks, and tests have shown it is valuable also on small foundations and almost anywhere that it is necessary to weld a piece at right angles to a flat plate.

Yours truly,
ELISHA PENNIMAN

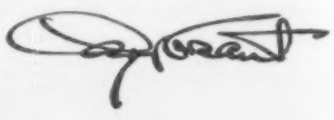
ARCOS WESTERN REPRESENTATIVE

Victor Equipment Company is now handling the complete line of stainless and alloy electrodes manufactured by Arcos Corporation, Phila., Pa. This organization, which is well known on the coast, has sales offices in Los Angeles, San Francisco, Fresno, Bakersfield, and San Diego, California, as well as in Phoenix, Arizona. Inquiries should be addressed to the nearest office.

I wonder if you're aware of the splendid job the USO is doing for the boys in the army camps and naval stations? Most of us in Hollywood have had the opportunity of seeing the results of work that's being done by this remarkable organization and because of that are giving it our whole-hearted support.

Everyone here has been mighty glad to be of help—some with money, others by giving shows at the camps—some have done both—but each one has pitched in to help in some way or another.

So, I'd like to put in my plea to everybody, everywhere, to make sure the USO gets the funds it needs. They keep up the spirit of your boys—your fighting men. So, come on, please dig deep, won't you, and give everything you can?



Send your contribution to your local USO chairman or to National Headquarters, USO, Empire State Building, New York City.

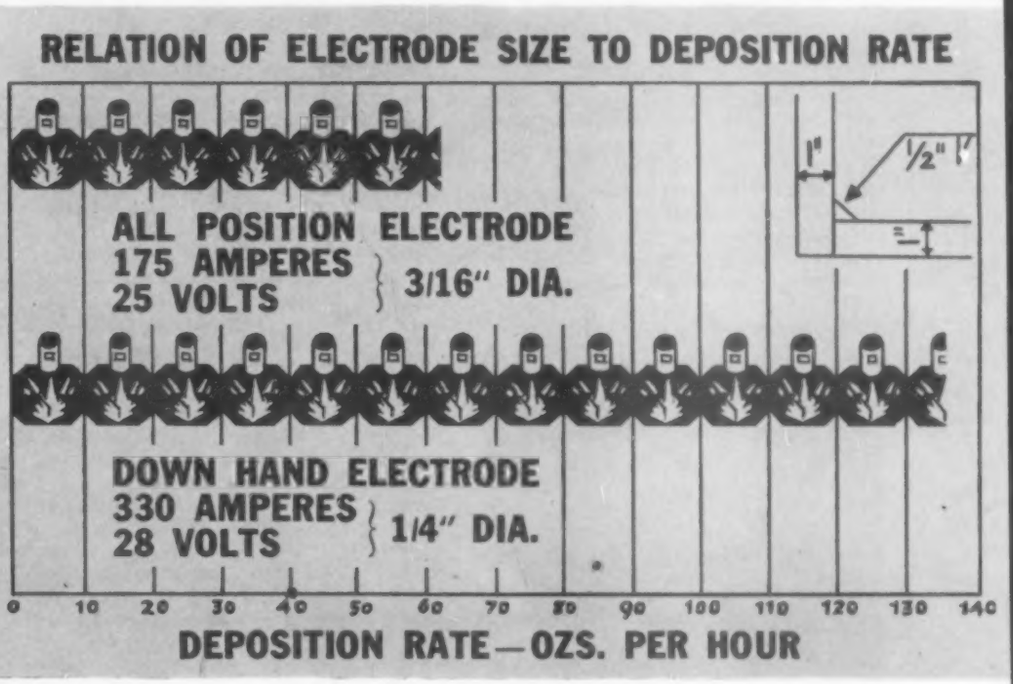
SUGGESTIONS TO HELP SPEED WELDED FABRICATION AND RELIEVE *the* ELECTRODE SHORTAGE

1

USE LARGEST ZE ELECTRODES POSSIBLE

2

SE ELECTRODES TH ALL-MINERAL COATINGS



In spite of the construction of new plants and tremendous increases in production, there is still a very definite shortage of welding electrodes.

The smaller sizes of electrodes and those of the all-position type cannot be manufactured as fast as the larger sizes and those with all-mineral coatings.

Electrode users can, therefore, help relieve the electrode shortage by using sizes as large as practical and by planning their work, so that whenever possible the all-mineral coated rods can be specified.

Using the larger diameter electrodes increases the speed of fabrication, too. For normally, when proper currents are used, the greater the electrode diameter, the higher is the resulting deposition rate. As shown in the above chart, in joining 1" plate with a ½" fillet weld, a 3/16" all-position rod deposits only 62 ounces of metal per hour, whereas a ¼" downhand "hot" rod at 330 amperes, deposits 135 ounces per hour, an increase of over 117%.

Murex engineers are available for consultation to manufacturers who are directly or indirectly engaged in war production — whether or not they are users of Murex electrodes.

Specialists in welding for nearly 40 years. Manufacturers of Murex Electrodes for arc welding and of Thermit for repair and fabrication of heavy parts.

AL AND THERMIT CORPORATION
120 BROADWAY, NEW YORK, N. Y.

MUREX
ARC WELDING ELECTRODES

BANY • CHICAGO • PITTSBURGH • S. SAN FRANCISCO • TORONTO

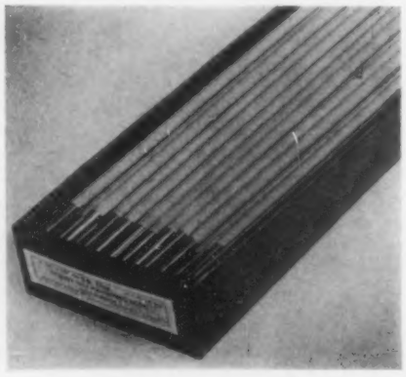
NEW PRODUCTS

The Society assumes no responsibility for the validity of claims in this Section

HARD-FACING RODS

To serve companies unable to furnish high priority ratings, the Stoody Company has developed two new hard-facing alloys which are being marketed under the trade names of Stoodite K and Stoody Self-Hardening K.

Stoodite K is a cast hard-facing rod consisting principally of molybdenum, tungsten, manganese, silicon, carbon and iron. It is supplied both in bare form for oxyacetylene application and in coated form for D.C. electric application. It is available in five rod sizes: 1/8, 3/16, 1/4, 5/16 and 3/8 in., and in rod lengths of 14 in. Deposits of Stoodite K average 54–58 on the Rockwell C scale, depending on the type of parent metal and the method of application.



Stoodite K is recommended for hard facing various types of agricultural tools, cement mill parts, brick and clay equipment, dredging and excavating equipment, etc.

Stoody Self-Hardening K is composed principally of molybdenum, manganese, silicon, carbon, vanadium and iron, and is made in the form of tubes with the mixed alloys on the inside. This rod is supplied bare for oxyacetylene application and bare and coated for D.C. electric application. It is available in three rod sizes: 1/8, 3/16 and 1/4 in. Electric rods are 14 in. in length, acetylene rods 28 in.

Deposits of Stoody Self-Hardening K average 50–54 on the Rockwell C scale depending on the type of parent metal and the method of application.

Stoody Self-Hardening K is recommended for hard facing tractor parts, sheepsfoot tamper shoes, roll crushers, jaw crushers, gyratory crusher heads, conveyor buckets, dredge pump impellers and other equipment subjected both to severe wear and impact.

Both Stoodite K and Stoody Self-Hardening K are available under the regular A-10, P-100 rating. Folders furnishing prices and specifications of the new rods may be obtained by writing to Air Reduction Sales Co. at 60 E. 42nd St., New York, N. Y.

COMPLETE LINE OF SEAM WELDERS

A complete line of seam welders, in three capacity ranges and 126 models, is announced by Progressive Welder Company, 3050 E. Outer Drive, Detroit, Mich.

In each of the light-, medium- and heavy-duty series, several standard throat depths are available, while each type is available in six different standard drives, three for circular and three for straight seam welding. The Universal model which may be used for both straight and circular welding is also available in three drive types and in each capacity range.

The new Progressive Seam Welders are designed for either interrupted or continous seam welding and incorporate all the latest developments in seam-welder design. They are attractively streamlined as well as ruggedly built.

Operating pressure in the new seam welders is obtained through a double-acting adjustable-stroke air cylinder mounted directly on head support of the machine. A double-action, solenoid-operated valve is used to control air pressure on the pressure (top) side of the piston as well as for the introduction of air at line pressure on the lower side of the piston for rapid return of the head. A speed control valve is supplied in the air lines to both intake and exhaust sides of the cylinder to reduce shock. The solenoid valve is operated through a two-stage foot switch. The first stage brings the upper wheel down on the work, while the second position starts the motor and sets welding wheels in motion simultaneously with closing of welding current circuit, the pressure switch being connected with the second stage of the foot switch.

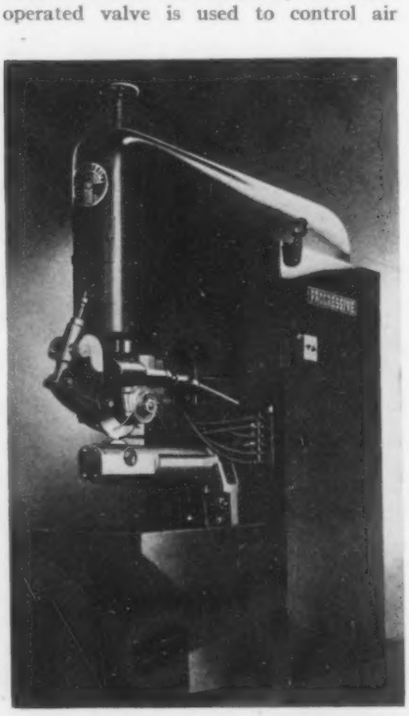


Fig. 1—One of the New Line of Progressive Seam Welders. The Model Shown Is of the Medium-Duty Universal Type Designed for Both Straight and Circular Seam Welding

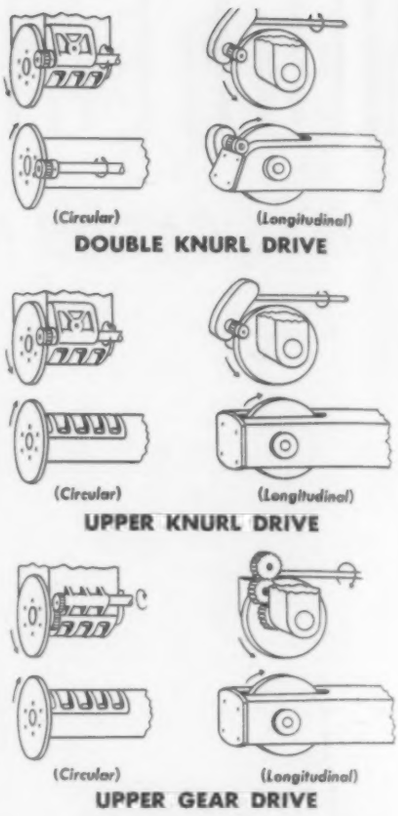
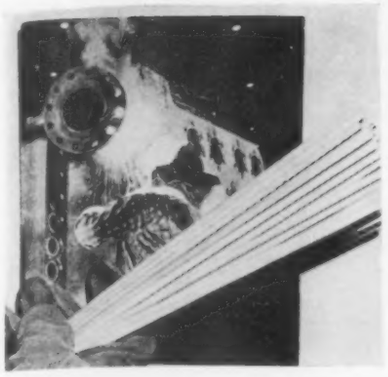


Fig. 2—Each Series of Progressive Seam Welder Is Available in Six Types of Drives, Three for Circular Welding and Three for Straight-Seam Welding

Welding heads are designed with full adjustment for wear. All surfaces are lubricated to insure long life and continuous perfect alignment. A special non-ferrous alloy is used to line the cast bearing housing, which is also internally water cooled. The shaft which this bearing supports is also available water cooled if desired.

ALL-POSITION A-C ARC WELDING ELECTRODE

An all-position, high-quality, alternating-current electrode, Type W-26, extending the advantages and convenience of *high-quality* a-c welding to both vertical and overhead positions, has been announced by the General Electric Company.



Alternating-current arc welding has already demonstrated its advantages for work in the horizontal and flat positions. The W-26, developed after intensive research, fulfills a long-felt need for a vertical and overhead a-c welding electrode that would give a high-quality job from the standpoint of physical characteristics as well as easy operation, adequate penetration and practically flat fillet contour.

Type W-26 electrode complies with the requirements of the following specifications: A.W.S. Filler Metal Specification E6011; Navy Bureau of Ships Specification 46E3, Grade 3, Class 1; and the A.S.M.E. Boiler Code, Paragraph U68.

By the use of this electrode, welding shops and fabricators, who have heretofore needed to supplement their a-c welders with stand-by d-c welders for high-quality work in the vertical and overhead positions, will now be able to release these machines for fabrication work where d-c welding may be essential.

BRAZING SAVES TIN

To save at least four tons of tin a year by eliminating the use of solder in the construction of electric motors and generators at the Westinghouse Electric and Manufacturing Company's East Pittsburgh works, this workman no longer connects by soldering—a tin-consuming process—the 432 wire connections in this electric motor. The two loose ends of copper wire now are clamped together and brazed, using a strip of phos-copper. No longer is solder (48% tin) required nor is tin needed to coat the copper wire ends as soldering formerly demanded.

LIGHT-GAGE AIRCRAFT STEEL WELDING INSTALLATION

A standardized flexible installation for the production spot welding in assembly of light-gage aircraft steels, including stainless steel types, has been developed by Progressive Welder Company. Incorporating a number of unusual features—such as refrigerated electrodes, variable throat depth, and welding transformer built right into a light-weight welding gun—the welding installation includes a jib crane with 6-ft. trolley-type arm.

Being completely self-contained, with all units mounted on, or suspended from the jib crane, the equipment is exceptionally easy to install and provides a wide area over which the equipment may be used—particularly useful in working on large assemblies or in combination with moving conveyors.

As an additional flexibility feature, the gun hanger is so designed that the gun may be swiveled 360° in any plane, facilitating welding in normally hard-to-get-at places on an assembly.

The gun, in spite of the built-in welding transformer, is light in weight and, in addition, is spring counterbalanced. It may be adjusted for throat depth merely by changing the electrode arms. Of the air-operated type (direct connection to factory airline system), the gun normally carries relatively small diameter electrodes. This permits obtaining of the needed welding pressure per square inch through a simple air cylinder mounted on the gun.

Fig. 1—New Welding Installation for Light-Gage Steels Comprises a Jib Crane, Refrigerating Unit, Electronic Timer and Welding Gun with Numerous New Features

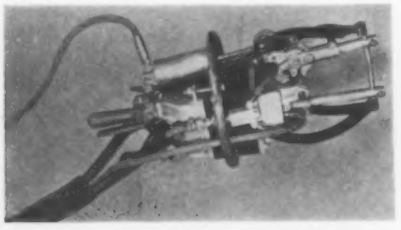


Fig. 2—Standardized Subassemblies for the New Light-Gage Air-Operated Gun Include Quick-Change Electrode Arms (to Vary Throat Depth), Built-in Transformer Eliminating Secondary Leads, Three-Step Heat Control Switch, Refrigerated Electrodes and Quick-Retracting Lever for Electrode Opening, Etc.

THREE BRAZES SIMULTANEOUSLY EVERY 35 SECONDS

The problem of brazing a $^{3}/_{4}$-in. threaded flange into a completely closed 20-gage sheet steel container was solved by Induction Heating.

Inductors, energized from a Model 1070 Thermonic Induction Generator, were placed directly over the flange and caused heating of the flange and a small area of the sheet steel container.

With this process it was possible to perform three brazes simultaneously in 35 sec.

A pre-placed ring of silver alloy melted and flowed to form a perfect, airtight joint.

The temperature is controlled exactly to the brazed area and areas adjoining, with no annealing beyond, and no metallurgical change.

Three units are brazed at one time. The strength of the braze is as high or higher than the original metal. As this joint is free from internal oxidation, the need for cleaning or other operation is greatly reduced.

FLAME-CUTTING TIPS

Two additions to their line of oxyacetylene flame-cutting tips have just been announced by Air Reduction. The first, known as Style 108, is ideal for working in close quarters. It is bent in an offset shape, to permit cutting along a line $^{21}/_{32}$-in. from the vertical centerline of the torch head or barrel. This offset design meets

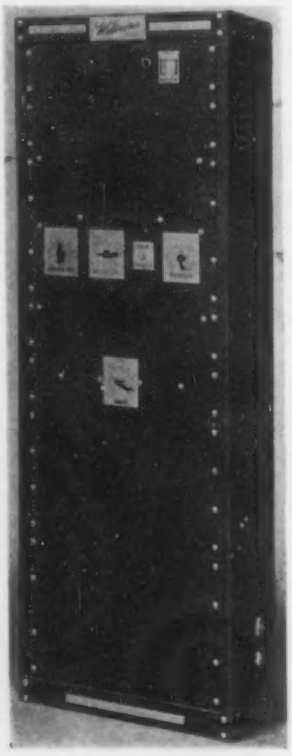
the problem of cutting close to bulkheads, flanges or shoulders where the radius of the torch head would prevent alignment of the cutting orifice vertically over the desired line of cut.

The Style 108 tip has milled flat sides, with two preheat flames, and is suitable for either machine cutting or hand cutting operations. It is available at present in sizes Nos. 1 to 3, for cutting steel up to $1^1/_2$ in. thick.

The other new addition to the line is the Style 139 straight tip with one preheat orifice, for certain machine cutting or hand cutting operations. This is a companion tip to the recently announced Style 119, which carries two preheat orifices. Made in sizes Nos. 0 to 3, Style 139 is particularly adapted to splitting angle iron, straight-line cutting using a straight edge as a guide, or sheet metal cutting operations, in which light preheat is desired. Further information about these or other tips in the Airco line may be obtained by writing to Air Reduction, 60 E. 42nd St., New York, N. Y.

SEAM WELDER CONTROLS

A new full-electronic timer and control designed for use with seam welders, as well as spot welders, is announced by Weltronic Corporation, E. Outer Drive, Detroit, Mich. When used with spot-welding machines, the new Model 40 timer provides both single shot and pulsation type welding controls.



Of the synchronous type, and incorporating phase-shift type heat control, the Weltronic 40 always starts and stops current flow at the zero point of the current wave, while the current duration is adjustable to the exact number of cycles desired.

The cabinet housing the control is of the standard Weltronic 4-panel type.

Provided in the timer is a built-in tube contactor (back of lower panel). The capacity of this contactor is the only necessary variable in the entire control to adapt it to varying capacities of welding operations. A wide selection of electronic contactors is available to suit specific requirements.

WELDING CLEAN-UP TIME CUT!

A practical solution to the time-wasting problem of cleaning up a job after welding recently was furnished industry by Turco Products, Inc. of Los Angeles and Chicago.

TURCO WELDMASK, a job-tested new development, prevents spattered molten particles, called "dingleberries" by the trade, from attaching themselves to the area surrounding the weld.

It is easily applied with a brush to the area most apt to be spattered, usually about three inches on both sides of the joint. The welding may be done through the TURCO WELDMASK and tests show it has no effect on the weld. After welding, the residue and molten particles can be removed with a hand wirebrush. Chipping with a hammer and chisel no longer is required.

TURCO WELDMASK, a creamy white liquid, is reasonably priced, non-injurious to the skin, hands or face; is non-inflammable, does not evaporate or give off fumes, and can be used on steel, stainless steel, aluminum or magnesium.

NEW WELDER

To meet the war need for continuous high duty mass production welding, the Ergolyte Manufacturing Company, Lawrence Street at Erie Avenue, Philadelphia, Pennsylvania, has just announced the development of a new heavy duty air-cooled arc welder, known as the 250 F. The new machine contains a built-in cooling system, and is heavier all around than its sister model the non air-cooled Ergolyte 250.

The war-time demand for virtually continuous welding prompted the development of this machine.

HOLLOW DRILL SPEEDS MICRO-SAMPLING

Much time is saved by using a tubular drill for extracting solid test samples from castings, forgings, rolled and welded parts at the Westinghouse Electric and Manufacturing Company, East Pittsburgh works. In addition, it is usually possible to sample without weakening the part being tested, and also the surface material (one end of the cylindrical sample) is preserved for inspection. The method replaces the slow and laborious procedure so commonly used to saw out specimens for microscopic analysis.

Essentially a tubular member having a number of cutting teeth at one end, the drill contains a removable centering device consisting of a pin and spring inside the hollow shaft. Held in the chuck of an ordinary stationary or portable air, electric, or hand drill, no jigs are required and the drill is operated in the conventional manner.

Fig. 1—MUCH TIME IS SAVED by Using a Tubular Drill to Remove a Solid Piece Sample from This 50-Ton Crane Hook at the Westinghouse East Pittsburgh Works. The Hook Is Not Weakened and the Metal Surface Is Preserved on One End of the Sample for Inspection

To use, a pilot hole approximately $^1/_8$ inch diameter and $^1/_8$ inch deep is made with a standard twist drill. The tubular member is then clamped in the chuck, the spring and the centering pin placed in the tubular member. The centering pin is positioned to extend beyond the drill teeth and the nipple is inserted in the pilot hole. When the drill has cut into the piece about $^1/_{16}$ inch, it is withdrawn to permit the pin and spring to drop out. Drilling is then resumed to the desired depth; the solid core formed inside the tubular shaft is removed from the part by flexing until it breaks off at the base.

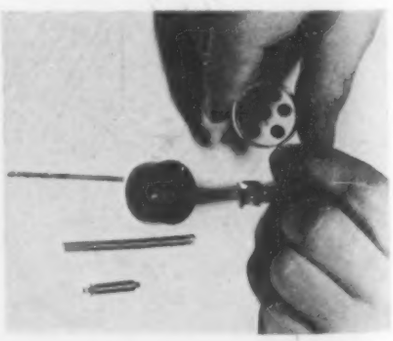


Fig. 2—SAMPLE REMOVED by Flexing Until the $^1/_8$ Inch Cylindrical Piece Breaks Off at the Base

SECTION ACTIVITIES

COLUMBUS

At the May meeting of the Ohio State University Student Branch of the AMERICAN WELDING SOCIETY, it was the Society's privilege of having as its guest the national president, Col. G. F. Jenks. The meeting was the second annual banquet, held May 8 at Pomerene Refectory on the campus.

The main speaker was Mr. Harry Jackson of the Battelle Memorial Institute of Columbus, who spoke on "What Industry Expects of the Graduate Engineer." He also told of his experiences in welding earth moving equipment.

Charles E. MacQuigg, dean of the College of Engineering, also a guest, spoke briefly on the importance of young engineering graduates in today's industrial war program.

Col. Jenks was then introduced by President Howard Cary. The great importance and magnitude of welding in the present war effort was stressed by Col. Jenks in his message to the student group. He also complimented the group on its success in founding the second student branch of the A.W.S.

The new officers for the coming school year were then installed. They are Clarence Shultheis, *President;* William Wagner, *Vice-President;* William Kearns, *Secretary;* and Simon Kadis, *Treasurer*.

Other guests at the meeting were Prof. John Younger, chairman of the Industrial Engineering Department; J. R. Stitt, professor of welding engineering; L. J. Rautio of the Department of Metallurgy; Fred Dahle, retiring chairman of the Columbus Section of the A.W.S.; Clay Roberts, new chairman of the Columbus Section; and George Mikhalapov, supervisor of welding research projects for the National Research Council.

After the dinner, the group attended the Columbus Section meeting at Battelle Memorial Institute, where Col. Jenks gave his main address.

CONNECTICUT

The following officers have been elected by the Connecticut Section for the fiscal year: *Chairman*, B. H. Perry, Bigelow Sanford Carpet Co.; *Vice-Chairman*, Ned Gilliland, Electroloy Co.; *Secretary*, Joseph Imperati, American Brass Co.; *Treasurer*, James Mitchell, Farrel-Birmingham Co.

INDIANA

The Indiana Section held its regular June meeting on June 5th and Anderson, Ind., was the host for the evening. A lovely dinner was served at the Anderson Y.M.C.A. and approximately eighty members and guests attended this dinner and the meeting which followed. The speaker was Mr. E. F. Holt, Research Engineer, P. R. Mallory & Co. Inc., Indianapolis, Ind. His subject was "Some Problems Connected with Cooling Spot Welding Electrodes." Every one enjoyed this very instructive talk.

Many local guests became interested in the AMERICAN WELDING SOCIETY through this meeting and some new members are expected from the Anderson area. Mr. Ray Wirt, the speaker for the last meeting, arranged this very successful meeting and the chapter officers appreciated his assistance.

No summer meetings have been planned to date but the officers expect to have several summer board meetings to formulate plans for the 1942–43 series of meetings.

LOS ANGELES

At a meeting of the Los Angeles Section held on May 21st the election of the following officers was announced: *Chairman*, Francis H. Stevenson, Vega Aircraft; *Vice-Chairman*, Alex Maraduden, Standard Oil Co.; *Secretary-Treasurer*, E. O. Williams, Victor Equipment Co; *Directors:* (for two years) Mr. Brumbaugh, Charles Babbit, C. W. Johnson; (for one year) M. J. Karnes.

The speaker was Mr. J. Washburn, Chief Photographer, Lockheed-Vega Aircraft Corp., who covered the subject of the "Photographic Templates." This relatively new tool of the aviation industry is an important cog in speeding the production of aircraft. It is estimated that two million dollars a year are saved in this one plant by using this process.

LOUISIANA

The Louisiana Section announces the election of a new Chairman and Secretary as follows: *Chairman*, George O. Huet, Higgins Industries; *Secretary-Treasurer*, A. E. Abaunza, Machine Welding Metal Works.

MARYLAND

New officers were installed by the Maryland Section at their May 15th meeting as follows: *Chairman*, Arthur R. Wynn, Maryland Drydock Co.; *Vice-Chairman*, Robert Fitzgerald; *Secretary-Treasurer*, VanRensselaer P. Saxe, Consulting Engineer.

MILWAUKEE

The Milwaukee Section announces its annual election of officers on May 22nd as follows: *Chairman*, Keith Walker, Bucyrus Erie Co.; *Vice-Chairman*, E. C. Breklebaum, Harnischfeger Corp.; *Secretary-Treasurer*, G. F. Meyer, Machinery & Welder Corp.; *Directors:* (for three years) Clinton Swift, Carl Malmberg, Rudd Mueller; (for one year) Chauncey Hart.

This was the annual "get-together" party at which the ladies were entertained at dinner, after which there was dancing and entertainment.

Mr. Otto C. Voss, who is retiring from his position with the Allis-Chalmers Company, was presented with an honorary membership of the Milwaukee Section.

NORTHWEST

The 5th annual meeting of the Northwest Section of the AMERICAN WELDING SOCIETY was held at the Covered Wagon, Minneapolis, Thursday, May 28, 1942, at 6:30 P.M., with Chairman J. H. Barron presiding. Approximately fifty members and guests were present.

After a "sizzling" steak dinner, the chairman called the meeting to order and made a few brief appropriate remarks on the occasion of the 5th annual meeting. He called upon the secretary-treasurer to present the financial and membership statements, which were ordered filed.

The report of the Nominating Committee was then presented, and on motion duly made and carried the nominees recommended by the Nominating Committee were duly elected to their respective offices. The new officers and members of the Executive Committee are as follows: *Chairman*, C. E. Comfort, Shop Supt., St. Paul Structural Steel Co., St. Paul; *Vice-Chairman*, John Mikulak, Mechanical Engineer, Electric Machinery Mfg. Co., Minneapolis; *Secretary-Treasurer*, Alexis Caswell, Secretary, Manufacturers' Association of Minneapolis, Inc.

Executive Committee: C. R. Brooks, Foreman, Edward E. Johnson, Inc.; Edgar E. Hall, Supt., Flour City Welding Co.; M. H. Hendrickson, Sales Engineer, Smith Welding Equipment Corp.; C. L. Hayward, Sales Representative, Williams Hardware Co.; T. P. Hughes, Assistant Professor of Mechanical Engineering, University of Minnesota; Louis T. Kenny, President, Kenny Boiler & Mfg. Co.; R. H. Newton, District Manager, Lincoln Electric Co.; R. W. Robinson, Manager, American Bridge Co.; R. L. Spaulding, Foreman, American Hoist & Derrick Co.; C. M. Underwood, Welding Engineer, Northern Pump Co.; T. J. Warmington Plant Manager, Wm. Bros. Boiler & Mfg. Co.; M. M. Weist, District Manager, Air Reduction Sales Co.; J. E. Williams, District Manager, Linde Air Products Co.

After the election a skit entitled "Mother Buys a Bond" was presented by a cast from the Northern States Power Company, and Ted Bellak, Director of

Motorless Flight Program, Minnesota Aeronautics Commission, spoke on "Gliding and Soaring." Colored movies showing glider construction and operation in the United States and Germany were then shown.

NORTHERN NEW JERSEY

New officers for the Northern New Jersey Section for the fiscal year are: *Chairman*, T. B. Smith, Federal Shipbuilding & Drydock Co.; *Vice-Chairman*, R. E. Powell, Western Electric Co.; *Secretary-Treasurer*, H. S. Card.

Executive Committee (for two years): F. G. Flocke, International Nickel Co.; Alexander Kidd, M. W. Kellogg Co.; P. F. McEvoy, Alloy Fabricators, Inc.; F. B. Swankhous, Electric Arc, Inc.; F. C. Fyke, Standard Oil Development Co.

Executive Committee (for one year): G. W. Nigh, Tidewater Associated Oil Co.; G. J. Blind, Midwest Piping and Supply Co.; K. W. Horsman, Worthington Pump & Machinery Co.; J. H. Bucknam, Linde Air Products Co.

PHILADELPHIA

The traditional May activity of the Philadelphia Section has been a plant visitation. The practical impossibility of making such arrangements under present conditions resulted in a decision to hold a May meeting at the Engineers Club, the section's usual meeting place. An interesting subject, "The Welding of High-Pressure Piping," covered by two well qualified members of the Philadelphia Section, proved by attendance figures to be as good a drawing card as any during the season. The lively discussion that followed demonstrated the interest in this topic in the Philadelphia area.

The welded fabrication of high-pressure piping for power and process piping was covered by Mr. H. J. Irrgang, Superintendent of the W. K. Mitchell Company, Philadelphia, and the special requirements and conditions to be met in marine construction were presented by Mr. H. O. Klinke, Welding Engineer, U. S. Navy Yard, Philadelphia.

Both speakers had interesting series of slides. Mr. Irrgang had excellent close-ups illustrating a concave head technique that, properly carried out, will result in a minimum of required chipping between passes. Among Mr. Klinke's slides was an excellent group of X-ray pictures illustrating good and poor joints. One poor joint caused by defective pipe material was a morale booster to the welders present, inasmuch as it definitely showed that all poor joints cannot be attributed to the welding-operators. In the talks and in the discussions following them a number of pertinent facts concerning electrodes were developed as were other items concerning down-hand *vs.* position-welding costs, shop handling and maintaining of dimensions.

Prior to the presentation of the speakers, the first part of the General Electric Company's series of color films, "The Inside of Arc Welding," was shown.

There will be no further regular Philadelphia Section meetings until fall. The Board of Directors, however, met in June to outline the program and other activities for the coming year.

ROCHESTER

New officers for the season 1942–43 for the Rochester Section are: *Chairman*, Robert L. Cattanach, American Laundry Machinery Co.; *Vice-Chairman*, Everett L. Hand, Gleason Works; *Secretary-Treasurer*, Paul W. James, The Lincoln Electric Co.

Executive Committee: Paul A. Ecklund, Delco Appliance Co.; Edward G. Habel, Eastman Kodak Co.; Harold King, University of Rochester; C. K. Martin, Taylor Instrument Co.; Joseph O'Rorke, Eastman Kodak Co.

SAN FRANCISCO

The April meeting of the San Francisco Section was held at the Westlake Jr. High School, Oakland, Calif., on April 17, 1942. There were approximately 175 members present. In the absence of Chairman Longo and Vice-Chairman Maltseff, Mr. C. S. Smith presided. The Secretary read a list of revised codes available as included in notice to the sections from the New York office. The following officers were elected: *Chairman*, Mr. F. A. Longo, Southern Pacific Company; *Vice-Chairman*, Mr. M. Maltseff, Western Pipe & Steel Co.; *Secretary*, Mr. R. E. Labagh, Victor Equipment Company; *Treasurer*, Mr. H. W. Saunders, Air Reduction Sales Co. The meeting was then addressed by Mr. W. L. Reichert of the Bethlehem Steel Company and Mr. Pat Doggett of the Moore Dry Dock Company. A very interesting open discussion was held, following these two talks. The meeting was adjourned at 10:00 P.M.

The May meeting was held on the 22nd at the Athens Athletic Club, Oakland. Prof. E. R. Mertz of Leland Stanford Jr. University presented an interesting talk on "Welding of Low-Alloy, High-Tensile Steels." Following the Question and Answer period, a sound, technicolor motion picture entitled "Unfinished Rainbows" was shown. This is a biography of the aluminum industry and was shown through the courtesy of the Aluminum Company of America.

SOUTH TEXAS

The South Texas Section concluded its spring series of meetings on June 4th at the Houston Engineers' Club, and will resume activities in September. Technical advisory committees will continue to function during the summer months as circumstances may require.

Mr. W. E. Klauberg of the Wyatt Metal and Boiler Works, Houston, Texas, was the principal speaker at the last meeting, and the subject discussed was "Preparation of Test Plates." This discussion covered all important points in the preparation and testing of plates for the qualification of welding procedure and operators in the flat position. Mr. Klauberg pointed out the importance of properly grooving the plate material and holding it in position as the welding begins. On reverse bends it is vital that the weld seam be chipped to "bright" metal before the inside bead is put on, and in all cases the machine setting should be carefully controlled to assure complete fusion and good penetration.

Members present were privileged to see several 16-mm. sound movies among which were: "Assembly Line of Defense" a film produced by direction of the Chrysler Corporation showing plant construction, tooling up and actual production of M3 tanks for the United States Army; "The Inside of Arc Welding," a full-color 16-mm. movie produced by the General Electric Company that is remarkable for its photography and the simple and direct manner in which it shows what actually happens at the welding arc.

WESTERN NEW YORK

The final meeting of the season was held Friday May 22nd, at the Markeen Hotel. The usual dinner meeting preceded the business meeting conducted by our new officers. A very interesting and instructive talk was given by Mr. Bankert, of the Production Welding Company of Detroit, and was thoroughly enjoyed by all.

All members are urged to participate in our second annual gold match to be announced shortly and it is hoped that a large turnout will be had.

YORK-CENTRAL PA.

On May 13th the York-Central Pa. Section held its final meeting of the season. The following officers were elected for the 1942–43 season: *Chairman*, W. B. Hollingshead, S. Morgan Smith Co.; *Vice-Chairman*, E. E. Rouscher, A. B. Farquhar Co.; *Secretary*, C. E. L. Kerchener, Southern Oxygen Co.; *Treasurer*, Vincent Risley, The McKay Co.

The Section also elected the following men to serve two years as directors: M. J. Van Dreser, George Hohman and Edward Shook. Directors who still have one year to serve are: E. J. Brady, J. E. Harris and L. H. Kemper. Mr. W. B. Lair, retiring chairman, automatically becomes a member of the Board of Directors.

Chairman Hollingshead then appointed the following men as committee chairmen: V. Risley, program; A. Heilman, membership; P. Dressel, publicity.

In addition to the annual election, two movie films were shown. The first, "The Romance of Iron and Steel," gave the story of iron and steel as processed by the American Rolling Mill Company. This movie gave the audience an interesting picture of the steps necessary from ore to finished product.

A full-color sound movie, "The Inside of Arc Welding," produced in the Raphael Wolff Studios of Hollywood and sponsored by General Electric Company, was also shown. This film showed the basic principles of shielded arc welding and described the four factors which determine the quality of a finished weld, namely:

length of arc, angle of electrode, current setting and speed of travel. This movie is very instructive to both welding operators and supervisors.

The monthly meetings will be suspended during the summer months and will be resumed in September.

NEW A.W.S. STANDARDS AND SPECIFICATIONS

Recommended Practices For Inspection of Fusion Welding (Tentative) (23 pages, heavy paper cover, price per copy $.40).

This report is the result of two years' work by an A.W.S. technical committee and represents a comprehensive treatment of the many factors involved in the inspection of welds made by the arc and oxyacetylene processes. The subjects covered include: qualifications of welding inspectors; duties of inspectors; inspection and testing of welded structures; inspection during construction; shop and field inspections; examination of welds; radiographic inspection, hydrostatic testing and magnetic powder inspection. A considerable part of the report deals with the welding characteristics of both ferrous and non-ferrous metals. These sections describe the principal types of defects that may be encountered, indicate their usual causes, and state how they may be detected and remedied. While most of the report deals with the inspection of welds in ferrous material, there is a considerable discussion of the non-ferrous metals, including copper and copper alloys, aluminum and aluminum alloys, and nickel and nickel alloys.

Definitions of Welding Terms and Master Chart of Welding Processes (32 pages, heavy paper cover, price per copy $.40).

A booklet giving the standard definitions of welding terms adopted by the AMERICAN WELDING SOCIETY. The terms are grouped under appropriate headings and subheadings so that closely related terms appear together and their relationships may be more readily understood. In addition the booklet includes an index in which all terms are listed alphabetically. Fifty-one illustrations assist in making the various definitions clear. The booklet also includes a chart showing the various subdivisions of the principal welding processes, namely, forge welding, resistance welding, arc welding, gas welding, thermit welding and brazing. (This bulletin is a revision of the 1940 tentative standard of the same title.)

Tentative Specifications for Iron and Steel Arc Welding Electrodes (8 pages, price per copy $.25).

A specification giving the dimensions, characteristics and properties of 30 different classifications of lightly coated and covered metal arc-welding electrodes for the welding of carbon and low-alloy steels. The specification prescribes certain tension and bend test requirements for welds made from these electrodes. (This specification is a revision of the 1940 tentative specification of the same title.)

Tentative Specifications for Iron and Steel Gas Welding Rods (5 pages, price per copy $.25).

A specification giving the dimensions, characteristics and properties of six different classifications of gas-welding rods for the welding of carbon and low-alloy steels. The specification prescribes certain tension and bend test requirements for welds made with these welding rods.

AMENDMENTS TO A.W.S. RULES FOR FIELD WELDING OF STEEL STORAGE TANKS

On May 7, 1942, the Board of Directors of the SOCIETY approved a list of amendments to the Society's Rules for Field Welding of Steel Storage Tanks (December 1940). These amendments are few in number and serve primarily to clarify the text as worded in the 1940 editions. The amendments have been published as a single sheet, gummed along one edge, suitable for insertion in the present bulletin.

Members of the SOCIETY who possess copies of the 1940 Rules for Field Welding of Steel Storage Tanks may obtain copy of the sheet of amendments at no charge, by addressing the AMERICAN WELDING SOCIETY, 33 West 39th Street, New York City.

NEW A.S.T.M. OFFICERS

Election of officers of the American Society for Testing Materials, for 1942–43 were announced at the Twelfth Session of the Forty-fifth A.S.T.M. Annual Meeting on Wednesday evening, June 24th, in Atlantic City, N. J.

Professor H. J. Ball, Lowell Textile Institute, Lowell, Mass., was elected President.

Mr. P. H. Bates, Chief, Clay and Silicate Products Division, National Bureau of Standards, Washington, D. C., was elected Vice-President.

Members of Executive Committee for two years: R. P. Anderson, Secretary, Division of Refining, American Petroleum Institute; Maurice H. Bigelow, Director of Technical Service, Plaskon Co. Inc.; J. H. Foote, Supervising Engineer, The Commonwealth & Southern Corp.; Alexander Foster, Jr., Vice-President, Warner Co.; Lawford H. Fry, Railway Engineer, Edgewater Steel Co.

1942 ANNUAL MEETING

Plans are under way for making this Annual Meeting one of the most important in the history of the AMERICAN WELDING SOCIETY. Every effort is being made to gear this meeting in with the War Production Effort. All the sessions have been arranged in such a way as to provide help to contractors who are, for the first time, engaged in the production of ordnance and other war production. Elsewhere in the JOURNAL there is given a tentative program of the Annual Meeting.

About the middle of July, members of the SOCIETY will receive a registration card from the Cleveland Hotel which should be returned promptly. Reservations will be at a premium.

Instead of a weekly session, the entire program has been condensed into four days. All frills and entertainment have been dispensed with. We will all miss the President's Reception and the Annual Dinner, but these are war days and an extra day away from home may be exceedingly important.

Find out about newest developments, latest advances in equipment, procedures and techniques. Solve your problems. Meet your personal obligation to learn all you can about welding as the most essential process in speeding war production. It's your patriotic duty to do this!

The Accent's on War!

War and how welding can help win it quickly and positively is the sole motivating force behind this year's meeting. Every paper, every speaker, every discussion, every feature of the program is planned to aid the war effort by making the latest, most pertinent and most authentic information on welding widely available for the benefit of war industry.

Other Features

It is impossible in this small space to describe in detail other special features such as a series of educational motion pictures on all phases of welding, research sessions, committee meetings, Section-Officers Conference, Business Meeting and the like.

Last but not least, the opportunity of meeting your fellow workers and discussing with them privately your problems is worth several times the time and effort of attending these sessions. These conferences materially aid in speeding up the war production effort.

Why You Should Attend the Annual Meeting of the American Welding Society This Year

1. Several societies will hold meetings at the same time in order to conserve time and money of people interested in the same field of endeavor. The meetings are held in conjunction with the National Metal Exposition.

2. Fifty-seven technical papers will be presented covering every phase of welding. The discussion which takes place in connection with the presentation of these papers is not available in any other way.

3. If you have a problem, there is no better opportunity available for a whole year to discuss with others interested in similar problems the difficulties you have encountered and how they may be overcome.

4. It provides an opportunity for executives to keep abreast of the latest developments in a condensed form and with a minimum amount of time and effort.

5. It is your duty to know the latest developments in training and technique of welding, in materials, in methods of inspection, in speeding up production, in improving quality, etc.

WELDING HANDBOOK

Available for Distribution July 15

Prepared by 250 of the leading welding experts of the U. S. A.

Worlds's greatest source of authentic, concise, authoritative welding information.

Completely revised and enlarged.

For a short time no restriction will be placed as to the number of copies which may be purchased by an individual Member or Company as the Society feels it essential to make this book available promptly to all workers on War projects.

Sustaining Members and Members of the A. W. S. will receive a free copy of the book; Associate Members and Operating Members will be able to purchase their first copy at $4.00. Extra copies can be purchased by all members from a supply reserved for this purpose at $5.00. Non-members $6.00 in the U. S. A.

1600 PAGES
1942 EDITION

TENTATIVE PROGRAM

TWENTY-THIRD ANNUAL MEETING AMERICAN WELDING SOCIETY WEEK OF OCTOBER 12, 1942

HOTEL CLEVELAND, CLEVELAND, OHIO

Make Room Reservations Early—Direct with Hotel Cleveland

Arrive Sunday 11th—(Convention Hotel) Rates Apply for Short or Long Stay

National Metal Exposition, Public Auditorium—Open Afternoons and Evenings Throughout the Entire Week, Commencing October 12, 1942

IMPORTANT

ALL Technical Sessions will positively start on time.

No Stenotype Reporter—Members desiring to discuss papers are urgently requested to prepare discussion in writing in advance of the meeting and to send copies to headquarters as those preparing written discussion will be given preference at the sessions. Members and guests giving extemporaneous discussion at meeting should forward a written transcript of discussion as soon as possible after the meeting.

Members and guests are urged to REGISTER immediately upon arrival at A. W. S. HEADQUARTERS and obtain Convention Badge admitting them to Exposition.

NO REGISTRATION FEE but a charge of $1.00 (per member) and $1.50 (non-member) is made for Technical Sessions Papers.

Registration hours throughout the week:

Hotel Cleveland
Monday, Tuesday and Wednesday 9 A.M. to 5 P.M.
Thursday 9 A.M. to 12 Noon

Public Auditorium
Monday, Tuesday and Wednesday 12 Noon to 10 P.M.
Thursday 12 Noon to 6 P.M.

MONDAY, OCTOBER 12th, Morning—9:30 A.M.

OPENING SESSION

Chairman—G. F. JENKS,
President, American Welding Society

Vice-Chairman—E. V. DAVID,
Chairman, Convention Committee

PRESENTATION OF MEDALS AND PRIZES

TECHNICAL SESSION—10:15 A.M.

TRAINING OF WELDING OPERATORS AND QUALIFICATIONS

Chairman—K. L. HANSEN,
Harnischfeger Corp.

Vice-Chairman—E. T. SCOTT,
Cleveland School of Welding

Training of Welding Foremen, by F. H. ACHARD, Supervisor of Training, Consolidated Edison Co. of New York, Inc.
Instruction Methods in Welding Developed by U. S. Office of Education, by H. K. HOGAN, U. S. Office of Education

OPENING METALS EXPOSITION—12:00 Noon

Monday Afternoon—2 : 00 P.M.

SIMULTANEOUS TECHNICAL SESSIONS

FATIGUE AND IMPACT

Chairman—A. E. GIBSON,
Wellman Engineering Co.

Vice-Chairman—F. L. PLUMMER,
Hammond Iron Works

Fatigue Strength of Metal Subjected to Combined Stresses
by L. H. DONNELL, Illinois Institute of Technology

Fatigue Strength of Commercial Butt Welds in Carbon Steel Plates
by W. M. WILSON, University of Illinois

Fatigue Tests of Full Thickness Plates with and Without Butt Welds
by E. C. HUGE and H. J. KERR, The Babcock and Wilcox Co.

Impact Strength of High Alloy Steel Welds
by E. C. CHAPMAN, Combustion Eng. Co.

WAR PRODUCTION

Chairman—R. J. KRIZ,
The James H. Herron Co.

Vice-Chairman—A. F. DAVIS,
The Lincoln Electric Co.

Some Special Applications of Flame Hardening
by STEPHEN SMITH, Air Reduction Sales Co.

High Quality Welding—Vertical and Overhead Positions with Alternating Current
by H. O. WESTENDARP, General Electric Co.

Conservation and Effective Use of Equipment and Supplies for Welding and Cutting
by H. ULLMER, The Linde Air Products Co.

Welding Gun Mounts
by W. B. LAIR, York Safe and Lock Co.

Monday Evening—7 :30 P.M.

MOTION PICTURE FILMS

The Inside of Welding—Educational film by General Electric Company

The Welding of Aluminum—Aluminum Company of America

Fundamentals of Oxyacetylene Welding—Courtesy Navy Department

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TUESDAY, OCTOBER 13th, Morning—9 :30 A.M.

SIMULTANEOUS TECHNICAL SESSIONS

WELDABILITY OF STEEL

Chairman—A. B. KINZEL,
Union Carbide and Carbon Res. Labs.

Vice-Chairman—A. G. BISSELL,
Bureau of Ships, Navy Dept.

Cooling Rates as Affecting Weldability
by G. E. DOAN and R. D. STOUT, Lehigh University

Effects of Cooling Rate on the Properties of Arc Welded Joints
by W. F. HESS, Rensselaer Polytechnic Institute

Weld Quench Gradient Tests
by W. H. BRUCKNER, University of Illinois

AIRCRAFT WELDING (Fuselage)

Chairman—P. H. MERRIMAN,
The Glenn L. Martin Co.

Vice-Chairman—J. F. MAINE,
Republic Structural Iron Works

Welding of Airplane Propeller Blades
by C. A. LIEDHOLM, Curtiss-Wright Corp.

Welding of New Types of Alloy Steels in Aircraft Structures
by A. R. LYTLE, Union Carbide and Carbon Res. Labs.

Effect of Current on the Welding of X4130 Aircraft Tubing
by W. T. TIFFIN, University of Oklahoma

Tuesday Afternoon—2 : 00 P.M.

SIMULTANEOUS TECHNICAL SESSIONS

WELDABILITY OF STEEL

Chairman—C. H. JENNINGS
Westinghouse Elec. and Mfg. Co.

Vice-Chairman—G. B. CARSON,
Case School of Applied Science

Bead Hardness and Bead Bend Tests on Carbon-Manganese Steels
by O. E. HARDER and C. B. VOLDRICH,
Battelle Memorial Institute

AIRCRAFT WELDING (Sheet)

Chairman—G. O. HOGLUND,
Aluminum Company of America

Vice-Chairman—JOHN D. GORDON,
Taylor-Winfield Corp.

Spot Welding in Aircraft Structures
by E. S. JENKINS, Curtiss-Wright Corp.

GAS CUTTING

Chairman—J. R. DAWSON,
Union Carbide and Carbon Res. Labs.

Vice-Chairman—C. A. LOOMIS,
Bureau of Ships, Navy Dept.

Tuesday Afternoon—2:00 P.M. (*Continued*)

SIMULTANEOUS TECHNICAL SESSIONS

WELDABILITY OF STEEL

Weldability of Carbon-Manganese Steels
by C. E. JACKSON, Naval Research Lab.

Jominy and Quench Tests on Carbon-Manganese Steels
by G. A. TIMMONS, Climax Molybdenum Company

T-Bend Tests of Carbon-Manganese Steels
by L. C. BIBBER and J. HEUSCHKEL, Carnegie-Illinois Steel Corp.

AIRCRAFT WELDING (Sheet)

Standards and Recommended Practices and Procedures for Spot Welding Aluminum Alloys
by G. S. MIKHALAPOV, Chairman, Aircraft Welding Standards Committee

Arc Welding of Magnesium Alloys
by W. S. LOOSE and A. R. ORBAN, The Dow Chemical Co.

Welding in Aircraft
by FRANCIS H. STEVENSON, Vega Aircraft Corp.

GAS CUTTING

Gas Cutting in Steel Mills
by S. D. BAUMER, Air Reduction Sales Co.

Improved Methods of Machine Flame Cutting
by H. E. ROCKEFELLER, The Linde Air Products Co.

Factors Affecting the Accuracy of Machine Cutting
by HOWARD HUGHEY and A. H. YOCH, Air Reduction Sales Co.

Evening—7:30 P.M.

Fundamental Research Conference—H. C. BOARDMAN, Chairman, Presiding

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WEDNESDAY, OCTOBER 14th, Morning—9:30 A.M.

SIMULTANEOUS TECHNICAL SESSIONS

RESISTANCE WELDING

Chairman—G. N. SIEGER, S-M-S Corporation

Vice-Chairman—B. L. WISE, Federal Machine & Welder Co.

Refrigerant Cooled Spot Welding Electrodes
by F. R. HENSEL, E. I. LARSEN and E. F. HOLT, P. R. Mallory & Co.

Spot Welding of Hardenable Steels
by W. F. HESS and D. C. HERRSCHAFT, Rensselaer Polytechnic Institute

Unusual Resistance Welding Developments and Operations
by R. T. GILLETTE, General Electric Co.

Resistance Welding Trench Mortar Fin Assembly
by J. H. COOPER, Taylor-Winfield Corp.

PRODUCTION WELDING

Chairman—O. B. J. FRASER, International Nickel Co.

Vice-Chairman—D. H. COREY, The Detroit Edison Co.

Welding with Aluminum Bronze
by CLINTON E. SWIFT, Ampco Metal, Inc.

Adapting Automatic Electric Welding to Routine Production
by J. M. KEIR, The Linde Air Products Co.

Welded Steel Tubing and Its Application in War Production
by H. S. CARD, Formed Steel Tube Institute

Wednesday Afternoon—2:00 P.M.

SIMULTANEOUS TECHNICAL SESSIONS

RESISTANCE WELDING

Chairman—R. E. POWELL, Western Electric Co.

Vice-Chairman—J. D. TEBBEN, P. R. Mallory & Co.

The Spot Welding of NAX High Tensile Steel
by C. R. SCHRODER, Great Lakes Steel Corp.

Application of Copper Oxides Rectifiers for Resistance Welding
by R. L. BRIGGS, Thomson Gibb Electric Welding Co.

The Effect of Weld Spacing on the Strength of Spot-Welded Joints
by R. DELLA-VEDOWA and M. M. ROCKWELL, Lockheed Aircraft Corp.

WELDING OF ORDNANCE

Chairman—H. L. R. WHITNEY, War Production Board

Vice-Chairman—H. C. BOARDMAN, Chicago Bridge & Iron Co.

Conservation and Substitution of Critical Materials in Filler Metals
by A. N. KUGLER, Air Reduction Sales Co.

Manual and Automatic Welding of Heavy Plate of Hardenable Alloys
by L. A. DANSE, Cadillac Motor Car Co.

Developments in Cast Iron Welding Rods and Electrodes
by R. J. FRANKLIN, Chicago Hardware Foundry Co.

SHIPBUILDING

Chairman—DAVID ARNOTT, American Bureau of Shipping

Vice-Chairman—A. L. PFEIL, Universal Power Corp.

Suggested Methods Which Will Increase Welding Production and Decrease Welding Costs
by J. F. LINCOLN, Lincoln Electric Co.

Distortion and Shrinkage Problems in Ships and Other Large Structures
by LAMOTTE GROVER, Air Reduction Co.

Motor Boat Construction and Small Ships
by W. E. WHITEHOUSE, Defoe Shipbuilding Co.

Wednesday Afternoon—2:00 P.M. *(Continued)*

SIMULTANEOUS TECHNICAL SESSIONS

RESISTANCE WELDING

Preparation of Aluminum Alloys for Production Spot Welding
by T. E. PIPER, Northrop Aircraft, Inc.

WELDING OF ORDNANCE

Electric Welding of Mobile Artillery Gun Carriages
by G. E. CAMPBELL, Pettibone-Mulliken Corp.

SHIPBUILDING

Application of Welding in Submarine Construction
by E. H. EWERTZ, Electric Boat Co. and R. D. WEST, Manitowoc Shipbuilding Co.

Evening—7:30 P.M.

Section Officers Dinner and Conference

THURSDAY, OCTOBER 15th, Morning—9:30 A.M.

SIMULTANEOUS TECHNICAL SESSIONS

AIRCRAFT WELDING

Chairman—S. L. HOYT,
Battelle Memorial Institute

Vice-Chairman—E. VOM STEEG,
General Electric Co.

Utility Characteristics of Aircraft Electrodes
by C. B. VOLDRICH and R. D. WILLIAMS, Battelle Memorial Institute

Results of Survey on Current Arc Welding Practice in Aircraft Industry
by MAURICE NELLES, Chairman, Western Aircraft Welding Committee

Copper Welding for Aircraft
by T. V. BUCKWALTER, Timken Roller Bearing Co.

NON-DESTRUCTIVE TESTS AND INSPECTION

Chairman—J. J. CROWE,
Air Reduction Sales Co.

Vice-Chairman—O. R. CARPENTER,
Babcock & Wilcox Co.

Correlation of Metallographic and Radiographic Examinations of Spot Welds in Aluminum Alloys
by DANA W. SMITH and FRED KELLER, Aluminum Company of America

The Magnetic Powder Method for Inspecting Weldments and Castings for Sub-Surface Defects
by CARLETON HASTINGS, Watertown Arsenal

Radiographic Inspection of Welded Armor Plates and Castings
by DON M. MCCUTCHEON, Ford Motor Company

Visual Inspection of Arc Welds
by W. L. WARNER, Watertown Arsenal

Thursday Afternoon—2:00 P.M.

Business Meeting

3:00 P.M.

Board of Directors Meeting

WELDING HANDBOOK NOTICE

MEMBERS, AMERICAN WELDING SOCIETY.

Good news! The 1600 page Handbook representing the work of 270 of the leading welding experts will be ready about July 15th.

If you are an Associate, Operating or Student member of the American Welding Society you will shortly receive a coupon entitling you to purchase one copy of the book at the reduced price of $4.00. Sustaining Members and Members will receive a copy of the book without further charge. All classes of members may purchase additional copies of the book at $5.00 The needs of all members will be supplied first and in order to do so a quantity of the books will be reserved for this purpose until January 1st, 1943.

We urge that every member of the Society estimate the needs of his company and associates and send in their orders at the earliest opportunity.

M. M. Kelly, *Secretary*, American Welding Society
33 West 39 Street, New York, N. Y.